Amendment to the Northeast Water Quality Management Plan

Total Maximum Daily Load to Address Temperature in the Pequannock River Northeast Water Region

Watershed Management Area 3 (Pequannock, Wanaque, Pompton and Ramapo Watersheds)

Proposed: June 7, 2004
Established:
Approved (by EPA Region 2):
Adopted:

New Jersey Department of Environmental Protection
Division of Watershed Management
Bureau of Environmental Analysis and Restoration
P.O. Box 418
Trenton, New Jersey 08625-0418

CONTENTS

1.0 Executive Summary

In accordance with Section 305(b) of the Federal Clean Water Act (CWA), the State of New Jersey developed the proposed 2004 *Integrated List of Waterbodies* (36 N.J.R. 1238(b), March 1, 2004) addressing the overall water quality of the State's waters and identifying impaired waterbodies for which Total Maximum Daily Loads (TMDLs) may be necessary. The proposed 2004 *Integrated List of Waterbodies* identified eleven stream segments in the Pequannock River Watershed as being impaired for temperature, as indicated by elevated temperature levels. This report, developed by the New Jersey Department of Environmental Protection (Department), establishes thirteen TMDLs for temperature in the Pequannock River Watershed and its tributaries located in Morris and Passaic Counties, Watershed Management Area (WMA) 3 for the impaired segments as identified in Table 1.

Table 1: Temperature Impaired Stream Segments Located in the Pequannock River Watershed for Which Temperature TMDLs are being Established

Site Id #	Station Name / Waterbody	2002	2004
01382410	Macopin River at Echo Lake	Sublist 1	Sublist 5
PQ1	Pequannock River above Pacock	Sublist 4	Sublist 4
PQ3	Pequannock River below Pacock	Sublist 5	Sublist 5
PQ4	Pequannock River above Clinton	Sublist 5	Sublist 5
PQ5	Pequannock River below Clinton	Sublist 5	Sublist 5
PQ6 01382450	Macopin River at Macopin Reservoir	Sublist 5	Sublist 5
PQ7	Pequannock River above Macopin	Sublist 5	Sublist 5
PQ8	Pequannock River at Macopin Intake Dam	Sublist 5	Sublist 5
PQ10	Pequannock River - Butler	Sublist 5	Sublist 5
PQ11 01382800	Pequannock River at Riverdale	n / a	Sublist 3
PQ 14	Outlet Trib of Maple Lake	n / a	Sublist 5
PQ15	Apshawa Brook	n / a	Sublist 5
PQ16	Clinton Brook below Clinton Reservoir	n / a	Sublist 5

In the 2002 *Integrated List of Waterbodies* (35 N.J.R. 470(a), January 21, 2003), the Department identified seven temperature impairments in the Pequannock River and several of its tributaries. These impairments were carried over to the proposed 2004 *Integrated List of Waterbodies*, which identifed four additional segments as impaired for temperature. In the Integrated List of Waterbodies, segments are assigned to one of five categories. Sublists 1 through 4 include waterbodies that are generally unimpaired (Sublist 1 and 2), have limited assessment or data availability (Sublist 3), are impaired due to pollution rather than pollutants or have had a TMDL approved by the United States Environmental Protection Agency (EPA) (Sublist 4). Sublist 5 constitutes the traditional 303(d) list for waters impaired or threatened by one or more pollutants. Table 1 above identifies the stream segments proposed for TMDL preparation with their status on the *Integrated List of Waterbodies* both in 2002 and as proposed on the 2004 list. Two segments are not currently proposed for Sublist 5, but are included in this TMDL document. The segment of the Pequannock River above Pacock that was and continues to be listed on Sublist 4 was placed on Sublist 4 rather than Sublist 5 because the impairment is attributed primarily to beaver activity and not an anthropogenic source. Nevertheless, the implementation plan in this TMDL document will address the effects of beaver activity and so inclusion of this segment within the set of temperature TMDLs is appropriate. The segment of the Pequannock River at Riverdale that is proposed to be placed on Sublist 3 on the 2004 *Integrated List of Waterbodies*, an indication that there is a need for additional data to assess the status of the segment, is believed to be impaired based on the overall analysis of the watershed conducted during development of the TMDL. Therefore, a TMDL will be completed at this time for that segment. As a result, the proposed amendment to the Northeast Water Quality Management Plan will establish thirteen TMDLs that address temperature impairments as identifed in Table 1.

A TMDL is developed to identify all the contributors of a pollutant of concern and load reductions necessary to meet the Surface Water Quality Standards (SWQS) relative to that pollutant. The pollutant of concern for these TMDLs is temperature. The TMDL for each segment is based on a temperature-discharge relationship developed through correlations and regressions of measured data. The chief cause of temperature impairment is the significant modification of natural flow regime and heating of water that results from current reservoir management practices. Beaver activity, which results in ponding of water, stormwater runoff from paved areas and detention facilities, and increased solar incidence in areas where shading vegetation is lacking in the riparian buffer also contribute to the temperature impairment. From this analysis, it has been determined that attainment of temperature criteria will require a combination of measures that will affect the causes of temperature impairment, including management of water allocation and reservoir operations, as well as addressing the effects of beaver activity, stormwater management practices, and conducting streambank restoration projects, where needed.

This TMDL Report is consistent with EPA's May 20, 2002 guidance document entitled, *Guidelines for Reviewing TMDLs under Existing Regulations Issued in 1992* (Sutfin, 2002) which describes the statutory and regulatory requirements for approvable TMDLs. This TMDL shall be proposed and, upon approval by EPA, adopted by the Department as an amendment to the Northeast Water Quality Management Plan (WQMP) in accordance with N.J.A.C. 7:15-3.4 (g).

2.0 Introduction

This report establishes thirteen TMDLs which address temperature impairment to the identified waterbodies (Table 1) in the Pequannock River Watershed. New Jersey's proposed 2004 *Integrated List of Waterbodies* identifies eleven stations on Sublist 5 (also known as the 303d list) as being impaired for temperature, two additional stations of concern for temperature impairment are found on Sublist 4 and Sublist 3, respectively. These TMDLs and the associated implementation plan provide the basis for a watershed restoration plan to address temperature impairments caused by various factors (deficient riparian vegetation, stormwater management, beaver activity and reservoir manipulation) in order to attain applicable SWQS for trout production (TP) and trout maintenance (TM) waters, thereby attaining and protecting the designated fisheries use. The stream segment stations known as Macopin River at Echo Lake and Pequannock River at Macopin Intake Dam are both listed for dissolved oxygen, while the latter is also listed for lead. Other pollutants include Fish-Mercury with impairments identified at the Canistear, Oak Ridge, Clinton and Echo Lake Reservoirs. A separate TMDL evaluation will be developed to address the other pollutants of concern. Therefore, these waterbodies will remain on Sublist 5 with respect to these pollutants until such time that a TMDL has been completed and approved by EPA. With respect to the thirteen temperature impairments addressed in this TMDL document, these waterbodies will be moved to Sublist 4 following approval of these TMDLs by EPA Region 2.

3.0 Background

In accordance with Section 303(d) of the Federal Clean Water Act (CWA) (33 U.S.C. 1315(B)), the State of New Jersey is required biennially to prepare and submit to the USEPA a report that identifies waters that do not meet or are not expected to meet SWQS after implementation of technology-based effluent limitations or other required controls. This report is commonly referred to as the 303(d) List. In accordance with Section 305(b) of the CWA, the State of New Jersey is also required biennially to prepare and submit to the USEPA a report addressing the overall water quality of the State's waters. This report is commonly referred to as the 305(b) Report or the Water Quality Inventory Report.

In November 2001, EPA issued guidance that encouraged states to integrate the 305(b) Report and the 303(d) List into one report. Following USEPA's guidance, the Department chose to develop an Integrated Report for New Jersey and has adopted the *2002 Integrated List of Waterbodies* and proposed the *2004 Integrated List of Waterbodies.* In preparation of the 2002 *Integrated List of Waterbodies*, the Department, for the first time, solicited data and information from the public for use in developing the list. The Department considered quality assurance / quality control, monitoring design, data age, and accuracy of sampling location information, data documentation and use of electronic format for data when deciding to use the submitted data. Data was also solicited for the proposed 2004 *Integrated List of Waterbodies.* The Pequannock River Coalition submitted data that was approved by the Department and used in the development of both the 2002 and the proposed 2004 *Integrated List of Waterbodies.*

The *Integrated List of Waterbodies* assigns waterbodies to one of five sublists. Sublists 1 through 4 include waterbodies that are generally unimpaired (Sublist 1 and 2), have limited assessment or data availability (Sublist 3), are impaired due to pollution rather than pollutants or have had a TMDL approved by EPA (Sublist 4). Sublist 5 constitutes the traditional 303(d) list for waters impaired or threatened by one or more pollutants, for which a TMDL may be required.

A TMDL represents the assimilative or carrying capacity of a waterbody, taking into consideration point and nonpoint sources of pollutants of concern, natural background and surface water withdrawals. A TMDL quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point and nonpoint sources in the form of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS).

Recent EPA guidance (Sutfin, 2002) describes the statutory and regulatory requirements for approvable TMDLs, as well as additional information generally needed for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations. The Department believes that the TMDLs in this report address the following items in the May 20, 2002 guideline document:

1. Identification of waterbody(ies), pollutant of concern, pollutant sources and priority ranking.
2. Description of applicable water quality standards and numeric water quality target(s).
3. Loading capacity – linking water quality and pollutant sources.
4. Load allocations.
5. Wasteload allocations.
6. Margin of safety.
7. Seasonal variation.
8. Reasonable assurances.
9. Monitoring plan to track TMDL effectiveness.
10. Implementation (USEPA is not required to and does not approve TMDL implementation plans).
11. Public Participation.

4.0 Pollutant of Concern and Area of Interest

Pollutant of Concern

The pollutant of concern for these TMDLs is temperature. Temperature levels in segments of the Pequannock River have been found to exceed New Jersey’s SWQS at N.J.A.C. 7-9B et seq., as reported in the adopted 2002 and proposed 2004 *Integrated List of Waterbodies.* Table 1 depicts the Pequannock River Watershed listings for temperature impairment. Table 2 and Figure 1 depict the spatial extent of the impairments. All of the listed impairments have a high priority ranking, as described in the proposed *2004 Integrated List of Waterbodies.*

The segment of the Pequannock River above Pacock that was and continues to be listed on Sublist 4 was placed on Sublist 4 rather than Sublist 5 because the impairment is attributed primarily to beaver activity and not an anthropogenic source. Nevertheless, the implementation plan in this TMDL document will address the effects of beaver activity and so inclusion of this segment within the set of temperature TMDLs is

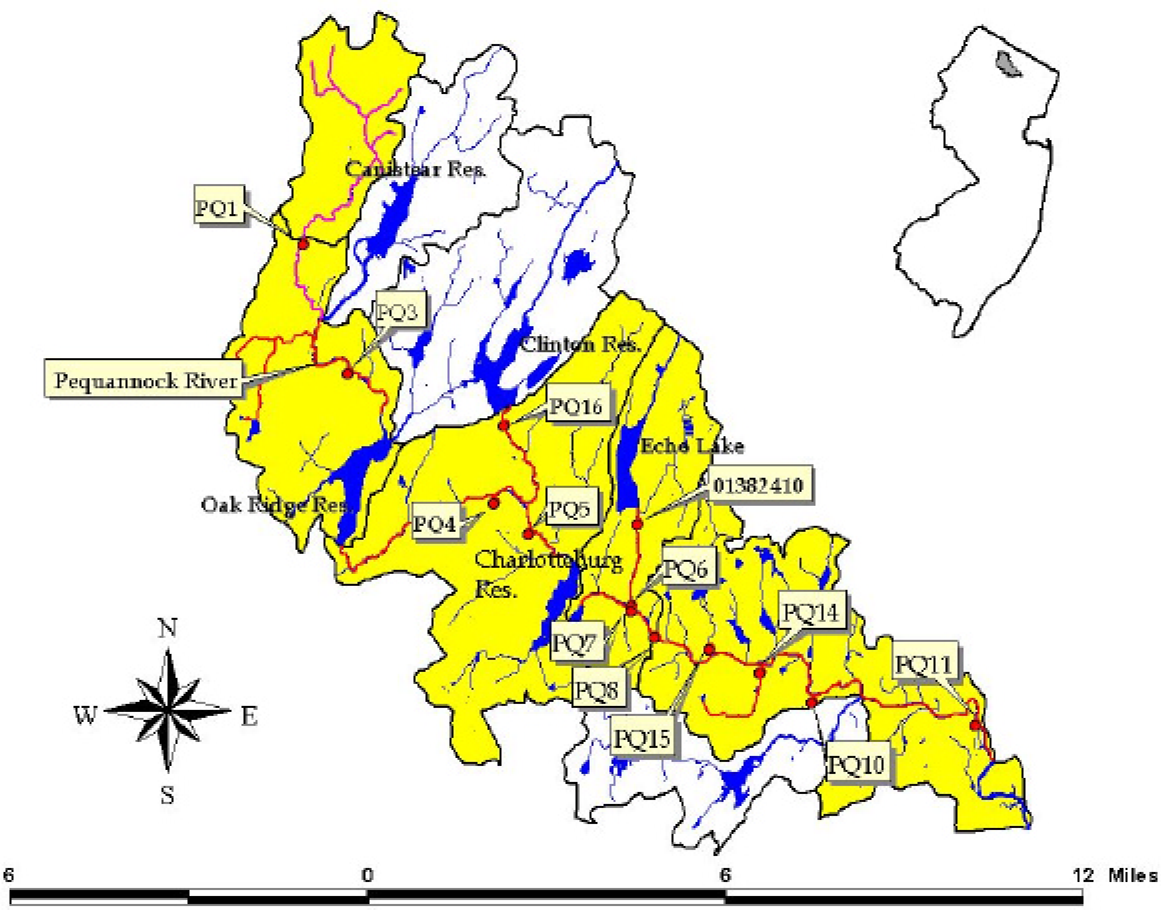
Table 2. Temperature impaired stream segments in the Pequannock River watershed, identified in the proposed 2004 Integrated List of Waterbodies, for which a temperature TMDL is being established.

<table>
<tr><th>Site ID</th><th>Sub -list</th><th colspan="2">Site Location and Waterbody/
General Description</th><th>Approx. River Miles</th></tr>
<tr><td>PQ1</td><td>4</td><td colspan="2">Pequannock River above Pacack Brook. Extends upstream to include all headwater tributaries, and downstream to confluence with Pacack Brook.</td><td>8.8</td></tr>
<tr><td>PQ3</td><td>5</td><td colspan="2">Pequannock River below Pacack Brook. Extends upstream to confluence with Pacack Brook, including unnamed tributaries east of Lake Stockholm Road and Holland Mountain Road, and downstream to Oak Ridge Reservoir.</td><td>6.6</td></tr>
<tr><td>PQ4 & PQ5</td><td>5
5</td><td colspan="2">Pequannock River below Clinton and Pequannock River above Clinton. Spatial extents overlap: mainstem only extending upstream to Oak Ridge Reservoir and downstream to Charlotteburg Reservoir.</td><td>3.9</td></tr>
<tr><td>PQ6 & 01382410</td><td>5
5</td><td colspan="2">Macopin River above Pequannock confluence and Macopin River below Echo Lake. Spatial extents overlap: extends from confluence with Pequannock River upstream to outfall of Echo Lake.</td><td>1.8</td></tr>
<tr><td>PQ7</td><td>5</td><td>Pequannock River above Macopin.</td><td rowspan="4">Spatial extents overlap: encompasses entire stretch of Pequannock mainstem from the outfall of Charlotteburg Reservoir downstream to the confluence with Pompton River.</td><td rowspan="4">8.9</td></tr>
<tr><td>PQ8</td><td>5</td><td>Pequannock River below Macopin.</td></tr>
<tr><td>PQ10</td><td>5</td><td>Pequannock River at Butler.</td></tr>
<tr><td>PQ11</td><td>5</td><td>Pequannock River at Riverdale.</td></tr>
<tr><td>PQ14</td><td>5</td><td colspan="2">Tributary outlet of Maple Lake. Extends from confluence with Pequannock River upstream to unnamed waterbody.</td><td>2.0</td></tr>
<tr><td>PQ15</td><td>5</td><td colspan="2">Apshawa Brook. Extends from confluence with Pequannock River upstream to Butler Reservoir.</td><td>1.2</td></tr>
<tr><td>PQ16</td><td>5</td><td colspan="2">Clinton Brook below Clinton Reservoir. Extends downstream to confluence with Pequannock River.</td><td>1.7</td></tr>
<tr><td colspan="5">Total River miles = ~34.9</td></tr>
</table>

appropriate. The segment of the Pequannock River at Riverdale that is proposed to be placed on Sublist 3 on the 2004 *Integrated List of Waterbodies*, an indication that there is a need for additional data to assess the status of the segment, is believed to be impaired based on the overall analysis of the watershed conducted during development of the TMDL. Therefore, a TMDL will be completed at this time for that segment.

The Pequannock River Watershed contains approximately 153.2 total river miles, of which 34.9 are impaired for temperature. More river miles are covered under these TMDLs than are actually listed as being impaired for temperature due to the fact that the implementation plans, as described in detail later in this document, cover entire watersheds, not just impaired waterbody segments. Thus, these TMDLs will provide restoration and/or protection from temperature impairment in nearly 23 percent of the Pequannock River Watershed.

Figure 1: Spatial Extent of Impaired Segments for which TMDLs are Being Developed



Description of the Pequannock River Watershed

Watershed Management Area 3 (WMA 3) includes watersheds that drain the Highlands portion of New Jersey. WMA 3 lies mostly in Passaic County but also includes parts of Bergen, Morris, and Sussex Counties and is comprised of 21 municipalities that lie entirely or partially within the watershed boundary. There are four watersheds in WMA 3: Pompton, Ramapo, Pequannock and Wanaque River Watersheds. The Pequannock, Wanaque and Ramapo Rivers all flow into the Pompton River. The Pompton River is, in turn, a major tributary to the Upper Passaic River. WMA 3 contains some of the State's major water supply reservoir systems including the Wanaque Reservoir, the largest surface water reservoir in New Jersey.

The Pequannock River Watershed is part of the Highlands physiographic province and is underlain by granite, gneiss and small amounts of marble of Precambrian age. These rocks, the oldest in New Jersey, were formed between 1.3 billion and 750 million years ago by melting and recrystallization of sedimentary rocks that were deeply buried, subjected to high pressure and temperature, and intensely deformed (The Geology of New Jersey, NJGS, 1986).

Spanning the heart of the Highlands Region with the longest stretch of wild trout water remaining in New Jersey is the Pequannock River Watershed. The Pequannock River is 30 miles long. Its headwaters are in Sussex County and it flows east, delineating the Morris/Passaic County line. It continues flowing east and joins the Wanaque River, which flows to the Pompton River in Wayne Township. The great majority of the land within the Pequannock watershed is forested and publicly owned. The City of Newark owns over 86 percent of the entire tributary area to the Pequannock River Watershed, which is the source of the city's water supply.

City of Newark Water Supply

In the 1800s the City of Newark was a major industrial center of New Jersey then, as it is today. Public officials found the increased population and manufacturing to be a formidable challenge. In particular, public officials had to figure out how to supply the city with fresh drinking water, and at the same time, manage wastewater from residences and industry. While residents of Newark could see and smell the impurities in the water from the Passaic River, then used for both water supply and waste disposal, there was little scientific evidence to demonstrate that the water was a threat to public health. As scientists began examining the water and writing reports testifying to the unsanitary nature of the water supply, Newark's public officials began to recognize that something would have to be done about the water supply for the citizens and industry of the City of Newark.

The East Jersey Water Company, which owned land in West Milford, agreed to supply Newark with a water system, complete for $6,000,000. It was proposed to build a dam in the Pequannock watershed, erect reservoirs to store water, build a pipeline to the Belleville reservoir, and then turn the plant over to the city. The Pequannock supply was placed on line in May, 1892. The initial system included the Oak Ridge, Clinton and Macopin Reservoirs. Water was fed from the Macopin intake through 21 miles of 48-inch pipeline (the Pequannock No. 1 Aqueduct) to the Belleville Reservoir in Newark.

Today, the City of Newark Water Department owns five reservoirs with a total capacity of 14.4 billion gallons located in the Pequannock River watershed and supplies water to over 400,000 residents outside of the watershed. The reservoirs include:

Canistear Reservoir
The Canistear Reservoir is the most upstream reservoir and is located almost entirely in Vernon Township, Sussex County and is formed by a dam on Pacock Brook. This 350-acre reservoir was used for storage and water released for diversion as water supply at Macopin intake dam on the Pequannock River prior to 1961. Currently, water is released for diversion at Charlotteburg Reservoir on the Pequannock River.

Oak Ridge Reservoir
The Oak Ridge Reservoir, which straddles Jefferson Township, Morris County and West Milford Township, Passaic County, is 482 acres. The reservoir was used for storage and water released for diversion at Macopin intake dam on the Pequannock River prior to 1961. Currently it provides water for diversion at Charlotteburg reservoir. Outflow is controlled mostly by operation of gates in pipes through the dam.

Charlotteburg Reservoir
The 149-acre Charlotteburg Reservoir is located between Rockaway Township, Morris County and West Milford Township, Passaic County. The spillway was equipped with an automatic bascule gate 5 feet high, but the gate has since been decommissioned. Water is diverted from the reservoir to serve the City of Newark.

Clinton Reservoir
The 423-acre Clinton Reservoir is located entirely within West Milford, Passaic County. The reservoir was used for storage and water released for diversion at Macopin intake dam on Pequannock river prior to 1961. Currently it provides water for diversion at Charlotteburg Reservoir. Outflow is controlled mostly by operation of gates in pipes through the dam. Releases from Clinton Reservoir, via Clinton Brook join the mainstem Pequannock River just above Charlotteburg Reservoir.

Echo Lake Reservoir

Echo Lake is also located in West Milford at Echo Lake Dam on Macopin River, 1.6 miles north of Charlotteburg Reservoir. The 300-acre reservoir has a drainage area of 4.35 square miles. Its capacity at the spillway is 1.58 billion gallons, unless flashboards are used, which provide an additional capacity of 180 million gallons. The lake is used for storage, and released water flows to Macopin intake for diversion to Charlotteburg Reservoir.

Macopin Reservoir

This 32 million gallon reservoir was one of the original reservoirs from the 1800's. It has since been decommissioned.

Sources: Water Resource Data New Jersey Water Year 2001, Volume 1. Surface-Water Data, Water-Data Report NJ-01-1, and the NJDEP, Division of Land Use Management, Water Monitoring & Standards, Bureau of Freshwater Biological Monitoring (BFBM) GIS coverage: Lakes with Name Attributes for the State of New Jersey.

Land Use

The predominant land use in the Pequannock River Watershed is undeveloped forest, water and wetlands. Urban land use is the main type of altered land use. There is very little agricultural land use. Table 3 depicts the breakdown of land use per watershed at the hydrologic unit code (HUC) 14 level. HUC delineations are part of a national system for identifying watersheds in a nested fashion that was developed by the United States Geological Survey, United States Soil Conservation Service and the US EPA. The HUC-11 code for the Pequannock is 02030103050 and this delineation can be further subdivided into HUC-14 drainage areas, which are then denoted by the addition of three digits as shown in Table 3 below.

Table 3. Pequannock River Watershed 1995-97 Land Use/Land Cover (by HUC 14) Total Area = ~55,569.3 acre²

HUC 14	Site ID	Agriculture	Barren	Forest	Urban	Water	Wetlands
010		0.0	0.0	2,796.7	75.2	64.0	528.0
020		12.4	0.0	3,479.7	69.6	335.0	693.3
030	PQ 1 PQ 3	7.3	0.0	4,851.0	366.5	513.9	970.8
040		8.3	0.0	6,760.5	139.8	719.5	858.0
050	PQ 4 PQ 5 PQ 16	128.3	62.7	8,315.1	1,233.9	365.5	1,654.7
060	01382410 PQ 6 PQ 7 PQ 8	20.3	10.0	3,203.6	760.1	353.9	699.9
070		18.3	200.4	5,655.2	3,734.2	417.5	810.1

080	PQ 10 PQ 11 PQ 14 PQ 15	0.0	0.0	2,476.5	1,611.7	331.2	256.7
? 's		194.9	273.1	37,538.3	7,991.0	3,100.5	6,471.5

Figure 1 shown previously highlights the HUC-14 watersheds which are impaired by temperature.

Data Sources

The Department's Geographic Information System (GIS) was used extensively to describe the WMA 12 watershed characteristics. In concert with USEPA's November 2001 listing guidance, the Department is using Reach File 3 (RF3) in the 2002 *Integrated List of Waterbodies* to represent rivers and streams. The following is general information regarding the data used to describe the watershed management area:

- Land use/Land cover information was taken from the 1995/1997 Land Use/Land cover Updated for New Jersey DEP, published 12/01/2000 by Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA), delineated by watershed management area.

- 2004 Assessed Rivers coverage, NJDEP, Watershed Assessment Group, unpublished coverage.

- County Boundaries: Published 11/01/1998 by the NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA), "NJDEP County Boundaries for the State of New Jersey." Online at: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/stco.zip

- Detailed stream coverage (RF3) by County: Published 11/01/1998 by the NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA). "Hydrography of Monmouth County, New Jersey (1:24000)." Online at: http://www.state.nj.us/dep/gis/digidownload/zips/strm/

- NJDEP 14 Digit Hydrologic Unit Code delineations (DEPHUC14), published 4/5/2000 by New Jersey Department of Environmental Protection, New Jersey Geological Survey (NJGS) Online at: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip

- NJDEP 10-meter Digital Elevation Grid of the Lower Delaware Watershed Management Area (WMA 12), published 12/23/2002 by NJ Department of

Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA) http://www.state.nj.us/dep/gis/digidownload/zips/wmalattice/wma12lat.zip

- NJPDES Surface Water Discharges in New Jersey, (1:12,000), published 02/02/2002 by Division of Water Quality (DWQ), Bureau of Point Source Permitting - Region 1 (PSPR1).

- Lakes/Reservoir information was taken from the Lakes with Name Attributes for the State of New Jersey GIS coverage (from 95/97 Land Use/Land Cover), published 2/12/2003 by the NJDEP-Bureau of Freshwater Biological Monitoring. Online_Linkage: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/njlakes.zip

- NJDEP Existing Water Quality Stations in New Jersey, published 5/12/2003, NJDEP, Division of Land Use Management (LUM), Water Monitoring and Standards, Bureau of Freshwater Biological Monitoring (BFBM), http://www.state.nj.us/dep/gis/digidownload/zips/statewide/ewqpoi.zip

- NJDEP Ambient Stream Quality Monitoring Sites, published 5/30/2001, NJDEP , Bureau of Freshwater Biological Monitoring (BFBM), http://www.state.nj.us/dep/gis/digidownload/zips/statewide/swpts01.zip

The spatial extent of impaired segments associated with each monitoring site were established using the methodologies described in the Integrated Water Quality Monitoring and Assessment Methods [Draft], established pursuant to Sections 303(d) of the Federal Clean Water Act, which can be accessed thru the Department's website at http://www.state.nj.us/dep/wmm/sgwet/wat/integratedlist/2004methodsdoc.pdf

5.0 Applicable Water Quality Standards

Temperature criteria have been established to protect aquatic life designated uses, and are based upon stream classifications. The criteria for stream classifications prohibit thermal alterations that would cause temperatures to exceed ambient temperatures by an established limit and, in addition, set a maximum temperature limit. The applicable surface water quality criteria under N.J.A.C. 7:9-1.14 (c) for the Pequannock River include:

FW2-TP No thermal alterations which would cause changes in ambient temperatures except where properly treated wastewater effluents are discharged. Where such discharges occur, temperature shall not deviate more than 0.6°C (1°F) above ambient temperatures or (20°C (68°F) used as a maximum temperature).

FW2-TM No thermal alterations which would cause temperatures to exceed ambient by more than 1.1°C (2°F) at any time or which would cause temperatures in excess of 20°C (68°F).

For the assessments in the Integrated Reports, the numeric limit of 68°F was used to determine impairment since ambient water temperatures for streams have not been calculated. (2002 Integrated Report p. 52)

The impaired segments covered under this TMDL are all classified FW2. Most support trout reproduction and are denoted as FW2-TP, while the remainder support maintenance of trout and are denoted as FW2-TM. The designated uses, both existing and potential, that have been established by the Department for such waters are as stated below:

In all FW2 waters, the designated uses are (N.J.A.C. 7:9B-1.12):

1. Maintenance, migration and propagation of the natural and established aquatic biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and
5. Any other reasonable uses.

6.0 Source Assessment

Based on an analysis of land use and stream hydrography, several key sources of temperature pollution have been identified. Point sources include stormwater outfalls, wastewater discharges and reservoirs. Stormwater outfalls, particularly those accumulating sheet flows from large areas of impervious cover such as asphalt parking lots, serve as sources of thermal increases during summer rain events. Wastewater discharges within the drainage area were analyzed.

There are a total of nine discharges to surface water (DSWs) that discharge either directly into the Pequannock River mainstem or one of its tributaries. To assess whether these discharges contribute to the temperature impairments along the Pequannock, the Department evaluated the Discharge Monitoring Reports (DMRs) for each of these facilities for the months of May thru October for the last 4 years. These most recent DMRs were chosen in order to best represent current conditions, as well as to provide a statistically relevant number of sample points. Five of the nine facilities are not required to monitor the temperature of effluent; therefore, no assessment of impact could be made for these facilities at this time. Those that do monitor for temperature are indicated in bold in Table 4 below.

Of the four facilities that monitor for temperature, three discharge to or within the associated spatial extent of an impaired segment, the exception being the West Milford Twp. MUA—Highview STP, which discharges into the Macopin River via Vreeland Pond, which then discharges directly into Echo Lake. Echo Lake is an impoundment greater than 50 acres and therefore, the spatial extent of the impairment of Macopin River below Echo Lake is determined to cease at Echo Lake. It must be noted however, that because the Macopin River discharges into Echo Lake immediately above the Lake's outfall, the potential that this facility does contributes to the impairment downstream cannot be ruled out. Also with regard to the four facilities that monitor for temperature, only the Butler WTP that discharges into Stonehouse Brook is not associated with trout maintenance or production waters. Figure 2 depicts the impaired sites and associated DSWs.

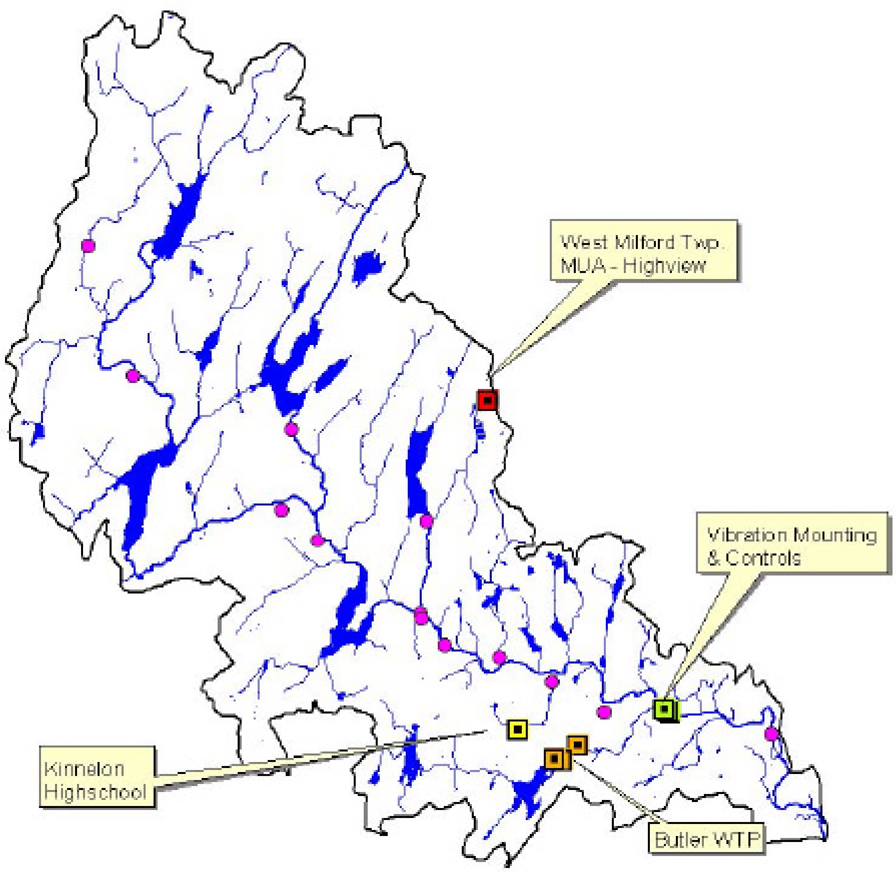
Table 4. Treatment works that discharge to surface waters in the Pequannock River watershed.

Facility Name	**Outfall Location**	**NJPDES #**	**Antideg Designation of receiving waters**	**Trout Designation of receiving waters**	**Monitors for Temperature (as a permit requirement)**
Newark-Pequannock WTP	Pequannock River / Charlotteburg Reservoir	0063711	C1	TP	NA
West Milford Twp. MUA-Highview	**Macopin River**	**0027685**	**C2**	**TM**	**YES**
Newark-Charlotteburg WTP	Pequannock River	0069582	C1	TP	NA
Kinnelon Twp High School	**Pequannock River via trib. Outlet of Maple Lake**	**0022284**	**C1**	**TP**	**YES**
Vibration Mounting & Controls	**Pequannock River**	**0025712**	**C1**	**TP**	**YES**
Butler WTP	**Stonehouse Brook**	**0025721**	**C2**	**NT**	**YES**
Passaic Crushed Stone Co.	Pequannock River	0025500	C1	TP	NA
Tilcon River Quarry Llc.	Pequannock River	0001601	C1	TP	NA
Peerless Concrete Products Inc.	Pequannock River	0127221	C1	TP	NA

Based on the DMRs, the Department has concluded that the effluent discharged from these facilities may have negatively influence the temperature of the receiving waters.

Table 5 in the Appendices depicts the volume and monthly average temperature of effluent discharged from the three facilities that are associated with trout maintenance or trout production waters. Quantifying an accurate percentage of the detrimental influence, however, is not possible without precise flow records for each receiving water, as well as temperature readings from both directly above and below each facility outfall(s). Permits will need to be modified to require ambient stream and effluent monitoring for all facilities to determine the effect. If a given facility does contribute to the temperature impairment of an associated segment, changes in permit conditions will be addressed in the next subsequent permit renewal.

Figure 2. Discharges to Surface water within the Pequannock River HUC 11 watershed. Circles indicate documented sites with temperature impairment.



The main cause for the temperature violations is the impact of the complex network of five reservoirs, with a combined volume of 14 billion gallons, within this watershed. In order to maintain the maximum amount of water in storage at any time, water is retained in the reservoirs unless released or when the volume of a reservoir is exceeded and excess water spills over the dam. Reservoir management practices that maximize retention of water in storage result in chronic low flows in the streams and, when reservoirs do exceed capacity in summer months, heated top water from spillways at Canistear, Oakridge, Charlotteburg and Clinton Reservoirs combine with chronically low, slow-moving waters to further increase water temperature. A diversion of Matthews Brook, which formerly connected directly with Macopin River, into Echo Lake increases the relative amount of heated top waters entering the Macopin River over the Echo Lake spillway. The decommissioned Macopin Reservoir, which is currently characterized as a shallow, slow-moving watercourse, allows additional opportunity for artificial heating of waters flowing into the lower Pequannock River.

Under normal conditions, the flow rate is often in the range of 0.5 to 2 cfs. Chronic low flows can alter the physical, chemical, and biological processes that affect the ecological integrity of the river. For example, low dissolved oxygen is often associated with high water temperature and two stations on the Macopin River are listed for oxygen impairment. Under low flow, most of the reaches in the Pequannock River are shallow and wide, which allows greater solar incidence and causes the water to heat and cool more rapidly. High water temperature with large diurnal variations can be lethal to aquatic life. This is critical in the Pequannock River, which supports an important cold-water fishery. The impact of reservoir operation on water temperature is evident through the observations of temperature violation occurrences, for example the least number of violations occurred during dry seasons (1999 and 2002) when reservoir discharges are minimal. Reservoir management geared solely to retention can also cause major flooding downstream from these reservoirs during high flow events, endangering both people and their properties. The Pequannock River has experienced a number of flooding events in recent years.

Nonpoint sources include direct runoff from land uses that promote heating, such as asphalt, which can result in elevated temperatures in the receiving water. In addition, beaver activity, particularly in the smaller first order streams of the Upper Pequannock River and Pacock Brook, results in the creation of wide, shallow ponds that absorb heat more than a free-moving stream would. Beaver activity also results in the loss of tree cover, which would otherwise moderate temperature elevation via shading. Past flooding by beaver dams has altered extensive land areas from forest to meadows including a half-mile section of Kanouse Brook in West Milford. Spot checks by the Pequannock River Coalition in this portion of Kanouse Brook have revealed temperatures much higher than the receiving segment of the mainstem Pequannock (Pequannock River below Clinton). Similar conditions exist in the Pequannock River headwaters (Pequannock River above Pacock). Lack of riparian buffer vegetation, resulting in loss of shading and associated temperature increases, also occurs in some locations as the result of development activities. A Department funded 319(h) Nonpoint Source Project described later on in this document under Long-Term Management Measures examined streambanks throughout WMA 3 and identifed candidates for habitat restoration and enhancement.

7.0 Water Quality Data

The Pequannock River Coalition was formed in 1995 in response to environmental threats within the watershed. The Pequannock River Coalition is dedicated to the preservation of the Pequannock River as a natural, recreational, aesthetic and water supply resource. Through a system of electronic devices the Pequannock River Coalition collects, analyzes and disseminates river and tributary water temperature data from monitored sites.

The Pequannock River Coalition monitoring program earned accreditation by the Department and their temperature data was used in the generation of the 2002 *Integrated List of Waterbodies* and again (under their expanded network) for the proposed 2004 *Integrated List of Waterbodies.* Additional data is attached in the appendices at the end of the document.

The two graphs below illustrate the frequency of temperature violations and flow durations for the period of record, 1998 through 2001. The first graph indicates that about 83% of the time, a temperature of 68 degrees Fahrenheit will be equaled or exceeded at Macopin Reservoir.

The second graph indicates that only 18% of the time a flow of 12 cfs is equaled or exceeded. Daily temperature variations range from less than a degree to about 10 degrees for Macopin Reservoir station.

Figure 3 Temperature –Duration Curve 1998-2001 June to August

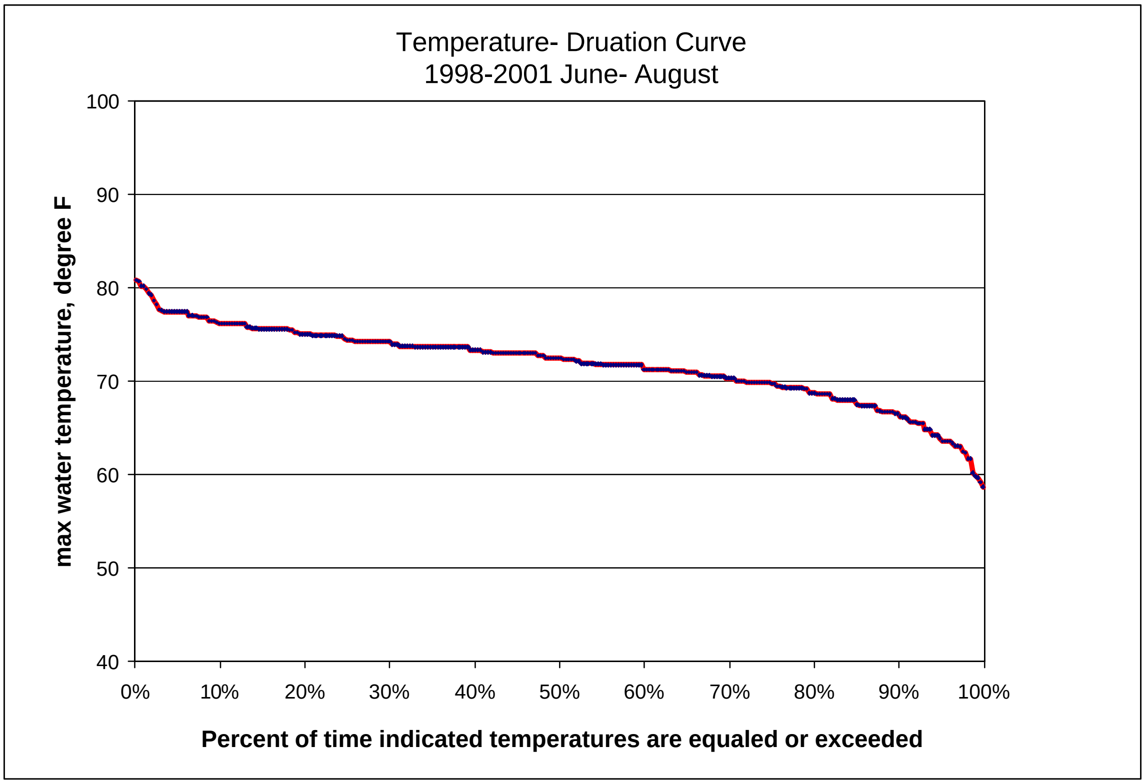
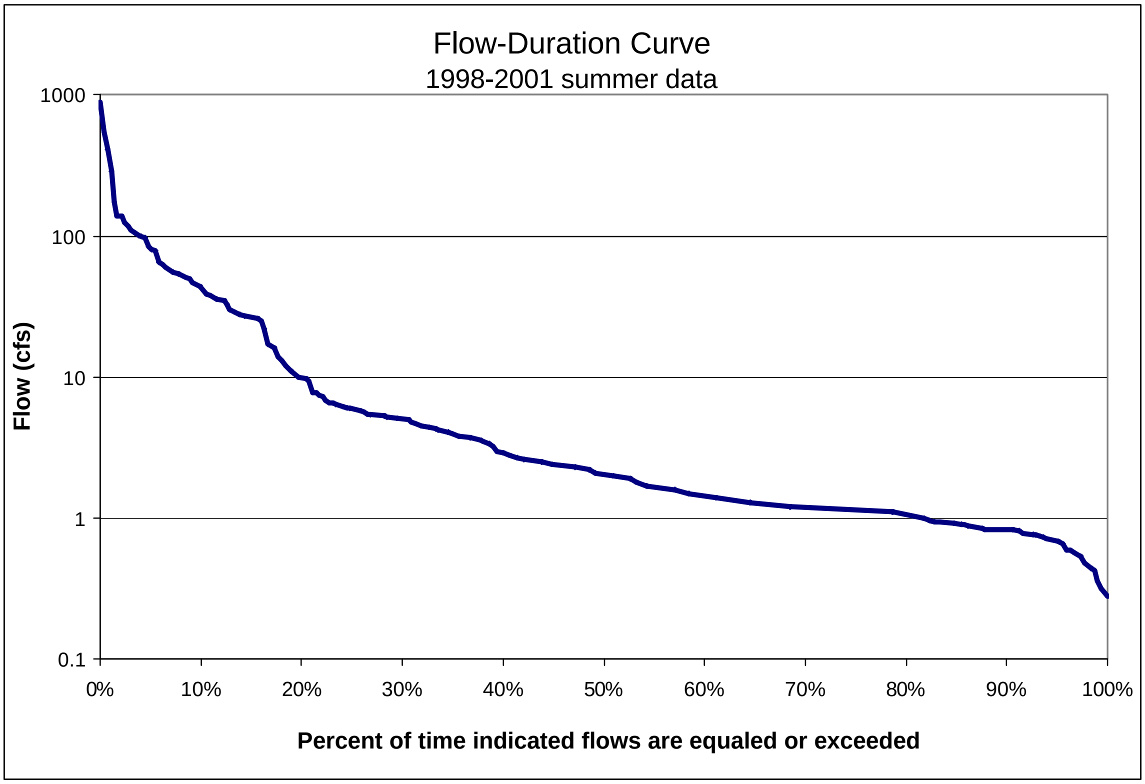


Figure 4 Flow –Duration Curve 1998-2002 Summer Data



Recent Pequannock River Fish Kills

Trout do best at temperatures of 52-68°F and temperatures higher than 78 can be lethal. The first documented and temperature related fish kill occurred on July 9-10, 1995. Water temperatures in excess of 83°F were measured at the Oak Ridge to Charlotteburg section of the Pequannock River. Dozens of dead trout and other fish were collected in this area.

The most recent fish kill occurred on July 3-4, 2002 in the same river section. Water temperatures reached a maximum of 80.8°F on July 3rd and 83.4°F on July 4th. A small number of dead trout and other fish were collected.

8.0 TMDL Calculations

Analytical Approach

The TMDLs will be expressed in terms of percent reduction of temperature violations. A modeling approach was used to determine the percent reduction in violations that can be achieved by establishing a passing flow at Macopin. The remaining percent reduction in violations needed will be assigned to the remaining point sources:

stormwater and wastewater discharges; and the nonpoint sources: beaver activity and riparian buffer vegetation gaps.

There are two types of models used to predict stream temperatures: empirical models and physical models. An empirical model uses statistical techniques to discern patterns or relationships among measured data. Physical models try to model the underlying processes that affect stream temperature, such as solar radiation, conduction, convection, evaporation, advection, stream geometry, dispersion and other factors. Physical or mechanistic models require extensive data input. Examples of such models are Stream Segment Temperature Model (SSTEMP) or Stream Network Temperature Model (SNTEMP). The model used for these TMDLs is an empirical model coupled with supporting data analyses.

The Department investigated the relationship between stream water temperatures, flow rate, and meteorological conditions (maximum air temperature and previous day average temperature) through correlations and regressions of measured data. An empirical regression model was developed based on the relationship between maximum water temperature, maximum air temperature, previous day average temperature and flow, using a total of 104 data points from summer 1999. In this system, water temperature is highly influenced by the operation of the reservoirs; therefore establishing a meaningful correlation between flow and water temperatures for the entire data set would require extensive data from the reservoir outlets. Lacking data sufficient to explain the non-steady state conditions, a data set that exhibited quasi-steady state conditions was used in the regression analysis. Data from summer 1999 (May 20-August 31), a total of 104 samples, served this purpose. An R^2 value of 0.95 was obtained when regressing maximum water temperature as a function of the following predictors: maximum air temperature, previous day average air temperature, and flow. Summer data for 2001 and 2002 also gave a strong R^2 values, 0.78 and 0.85 respectively, but 1999 has the best correlation among predictors and maximum water temperature. Use of 1999 data for the regression is appropriate because:

- 1999 data is characterized by low flows and above average air temperature. The most critical flow rates are in the range of zero to 20 cfs (82% of summer flows are below 12 cfs). Including elevated air temperature in the model input expands the model predictability to cover a wide range of meteorological conditions (70 to 100^+ degrees F).
- Flow and temperature data for summer 1999 reached a quasi-steady state condition. Analyzing a steady state condition has several advantages: first, it better demonstrates correlations among parameters if they exist and second, under steady state conditions, a model will be able to predict more clearly the effect of flow on water temperature, isolating this variable, because, during summer 1999, Newark did not release water from Charlotteburg Reservoir nor did the reservoir overspill.
- Although summer 1999 air temperatures data were the highest within the 1998 through 2002 summer data, it had the least number of water temperature violations.

Only 72% of the data exceeded the water temperature criteria of 68 degrees F compared to 85% for 1998, 86% for 2000, 86% for 2001, 82% for 2002, and an average of 86% violations for the entire set 1998-2002 data. Therefore, using 1999 data will not overestimate the flow requirement.

The regression approach has several advantages over physical models; for example, regression requires less input data and computation time. To complement this approach, a computational model was also used in the analysis. The input data for this model included all the data from 1998 through 2001. This aspect of the analysis investigates the impact of various minimum flow criteria on the number of days the maximum water temperature exceeded the temperature criteria. The strength of this approach is that computations are based on measured data, and are based on a longer period of record. Such a model was used in the Central Platte River, Nebraska as the basis for setting a minimum passing flow of 900 cfs to achieve compliance with water temperature criteria.

The analyses will be based on the most downstream impairment at Macopin, but the passing flow established for Macopin will address all the impairments upstream of Macopin station. The reasoning behind this approach is as follows: by requiring a specific passing flow below the Charlotteburg Reservoir, which is the most active downstream reservoir, water will need to be released from the upstream reservoirs to make up the discharge from Charlotteburg Reservoir. Such releases should be in proportion to the drainage area upstream of each reservoir to ensure adequate streamflow. Setting a minimum passing flow of 12.3 cfs at Macopin, based on watershed area ratios, the following passing flows at the other reservoirs are calculated as a guideline:

Charlotteburg Reservoir outlet: 88% of Macopin flow
Oak Ridge Reservoir outlet: 43% of Macopin flow
Clinton Reservoir outlet: 17% of Macopin flow
Canistear Reservoir outlet: 10% of Macopin flow
Echo Lake outlet: 7% of Macopin flow.

Regression Analysis

For the analyses, diurnal temperature data from Pequannock River Coalition (1998-2002), daily flow data from Macopin station, and air temperature data from national Climatic Data Center, NOAA were used.

Using a regression model, both linear and nonlinear regressions were explored; both approaches gave almost the same correlation, therefore the linear model was picked for simplicity and ease of application. The linear model has the following form:

$$T = a_0 + a_1 X_1 + a_2 X_2 + a_3 X_3$$

Where:
T = max water temperature
X1=flow rate (cfs)
X2= max air temperature
X3= previous day average temperature
a0, a1, a2, a3 are constant coefficients

Temperature data are available for a number of sites on the Pequannock River, and were collected during summer months since 1998. The only flow data available is at Macopin Reservoir, and no data is available on the operation of the reservoirs.
Data from year 1999 was selected to run the regression model for the reasons listed above. The regression model produces the following linear equation:

$$\mathbf{T_w = 29.22 - .453Q + .295\ T_a + .253T_{av}}$$

Where:
T_w= maximum water temperature
T_a= maximum air temperature
T_{av}= previous day average air temperature
Q = flow rate (cfs)

Solving for flow (Q), gives:

$$\mathbf{Q = 64.46 + .65\ T_a + .56\ T_{av} -2.21\ T_w}$$

To account for critical conditions, the minimum flow requirement for temperature control would be determined based on worst case scenarios. For the period of record 1998-2002, the highest air temperature occurred on August 9, 2001.

T_a = 99 degree F (maximum air temperature)
T_{av} = 82 degree F (previous day average air temperature)
T_w = 68 degree F (water temperature standard)
Q = **24.4 cfs** (the required minimum flow)

The following required minimum flows are calculated based on air temperatures selected to represent an average condition and meeting the water temperature standard of 68 degrees F:

T_a = 83.1 degree F (average maximum air temperature during summer 1999)
T_{av} = 71.3 degree F (average temperature during summer 1999)
T_w = 68 degree F (water temperature standard)
Q = **8.1 cfs** (the required minimum flow)

Table 6 below summarizes the output of these analyses.

SUMMARY OUTPUT

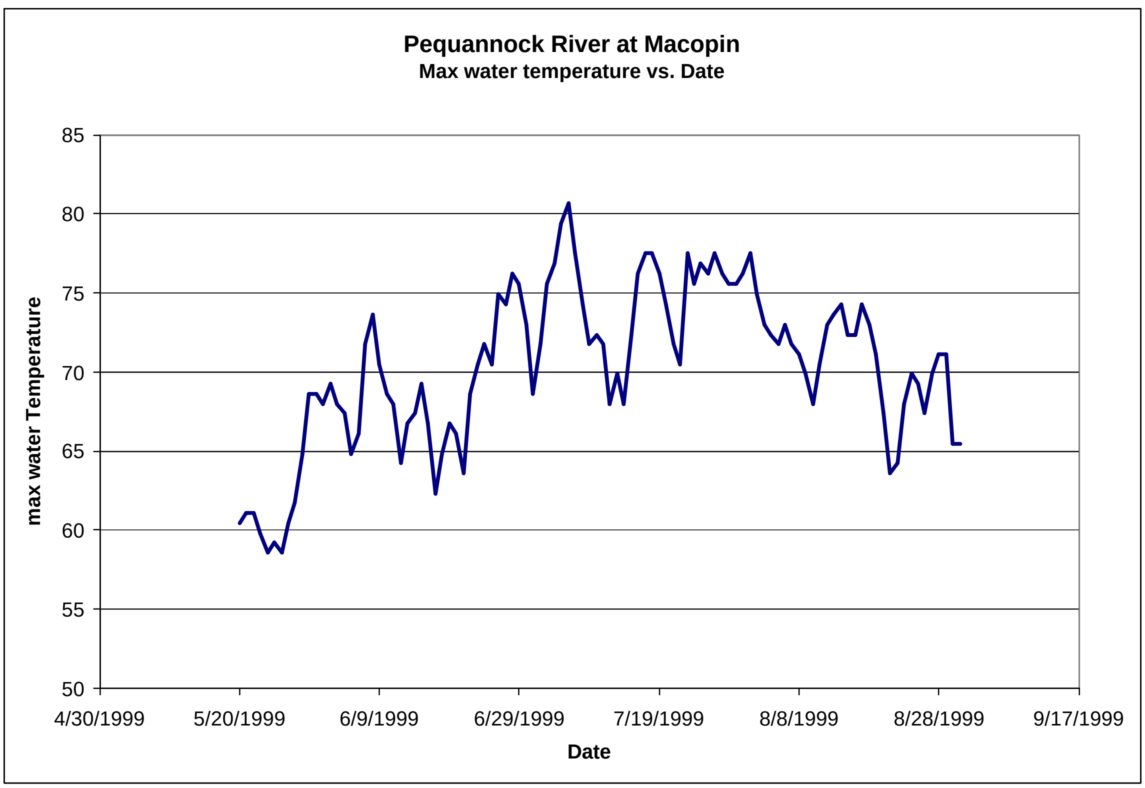
Regression Statistics	
Multiple R	0.972
R Square	**0.945**
Adjusted R Square	0.943
Standard Error	**1.206**
Observations	**104**

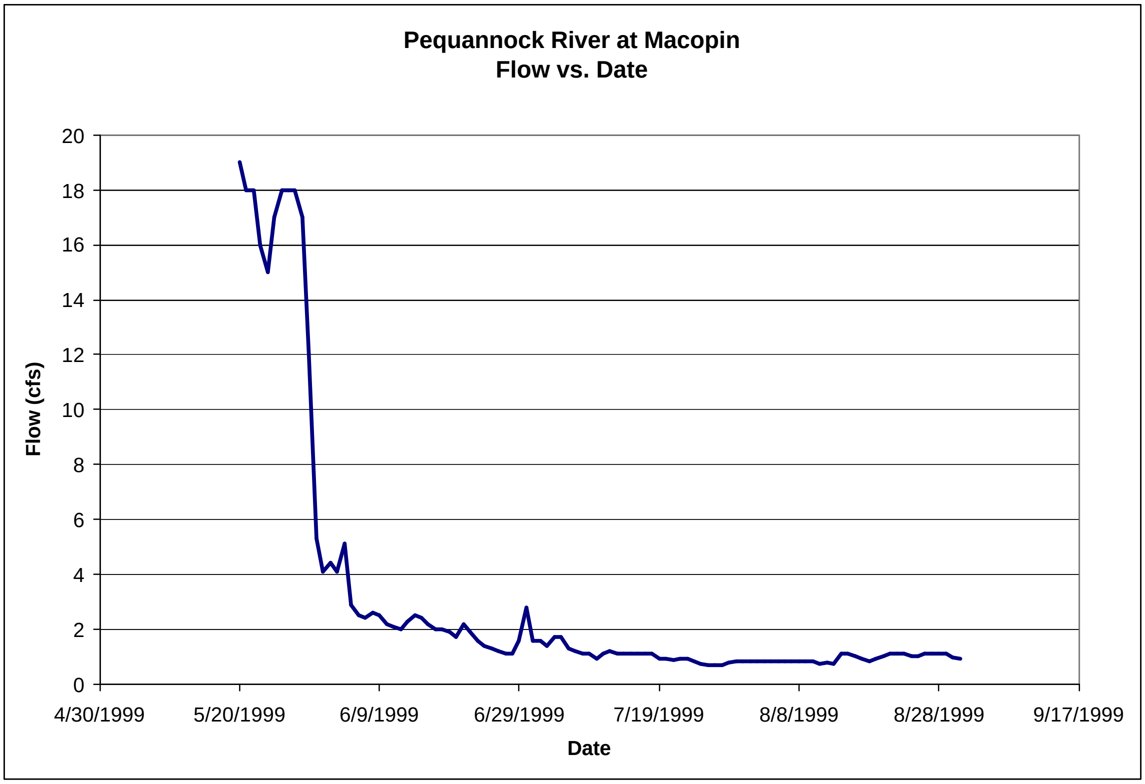
ANOVA

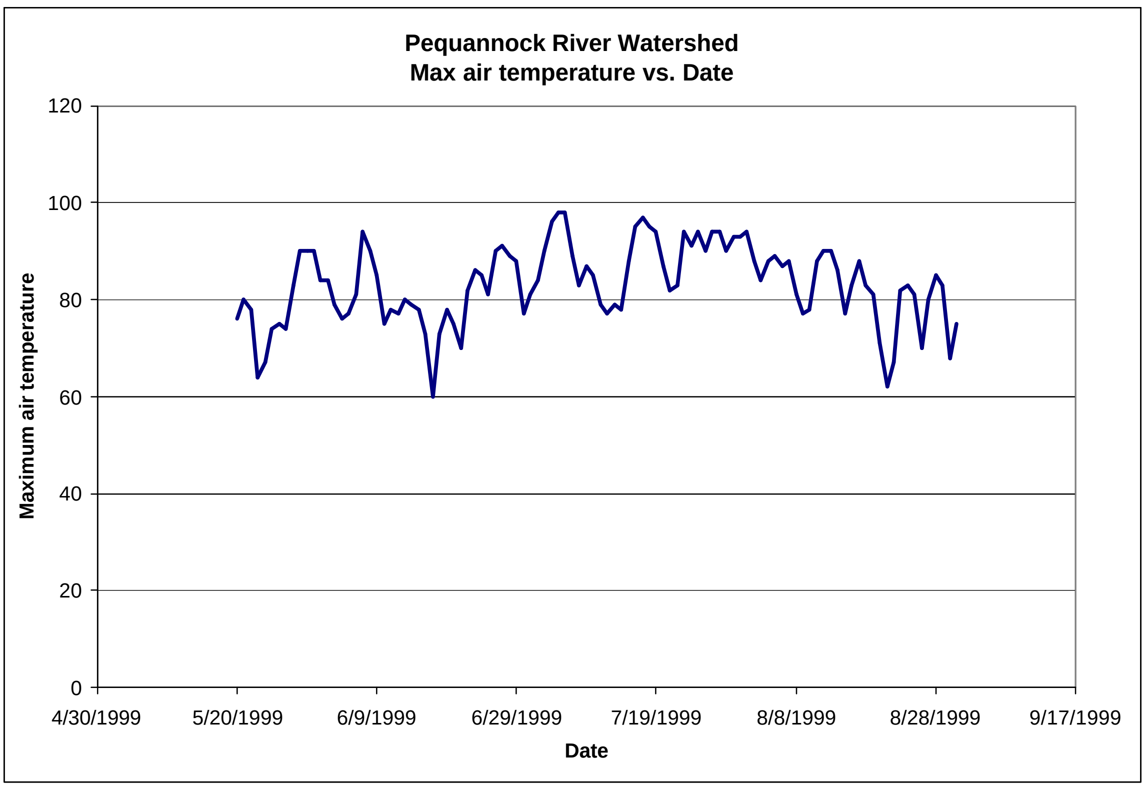
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2484.932	828.311	569.503	1.06E-62
Residual	100	**145.445**	1.454		
Total	103	2630.377			

	Coefficients	*Standard Erroı*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	29.224	1.463	19.974	1.11E-36	26.321	32.126
Flow (cfs)	**-0.453**	0.026	**-17.706**	1.37E-32	-0.504	-0.403
Max air temp	**0.295**	0.019	15.119	1.40E-27	0.256	0.333
Previous day avg. air te	**0.253**	0.024	10.558	5.92E-18	0.205	0.300

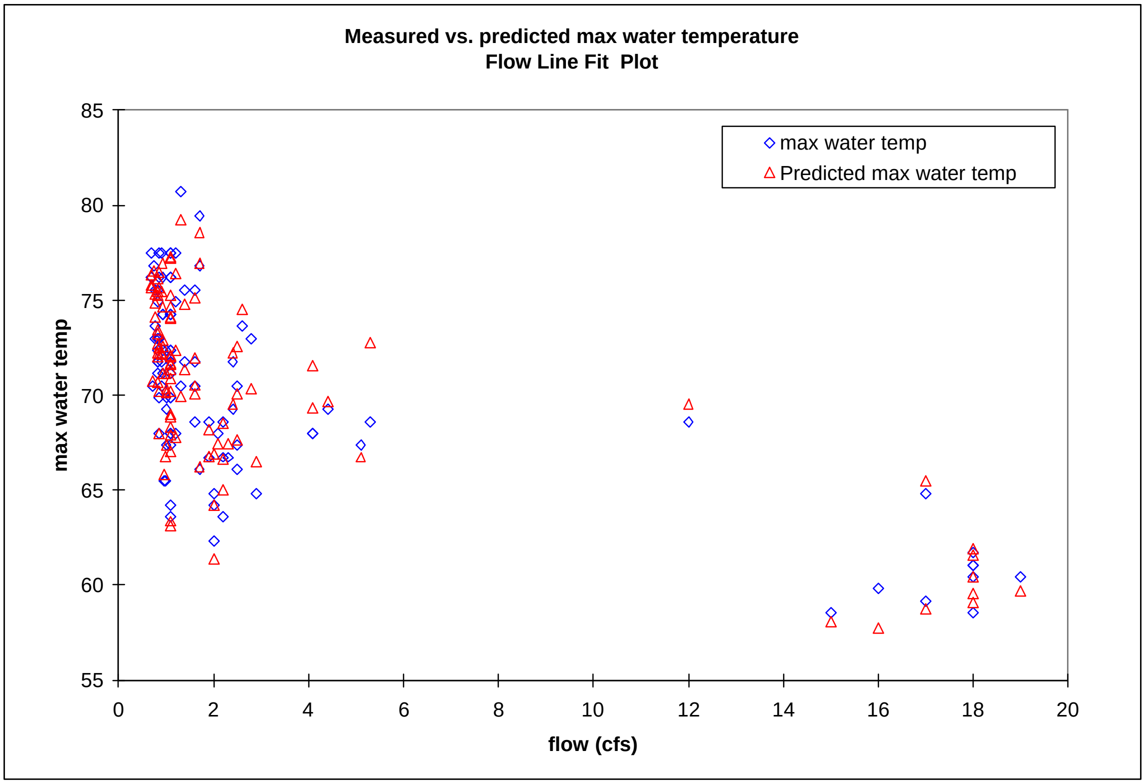
The next three graphs show the input data used in the regression with respect to date.

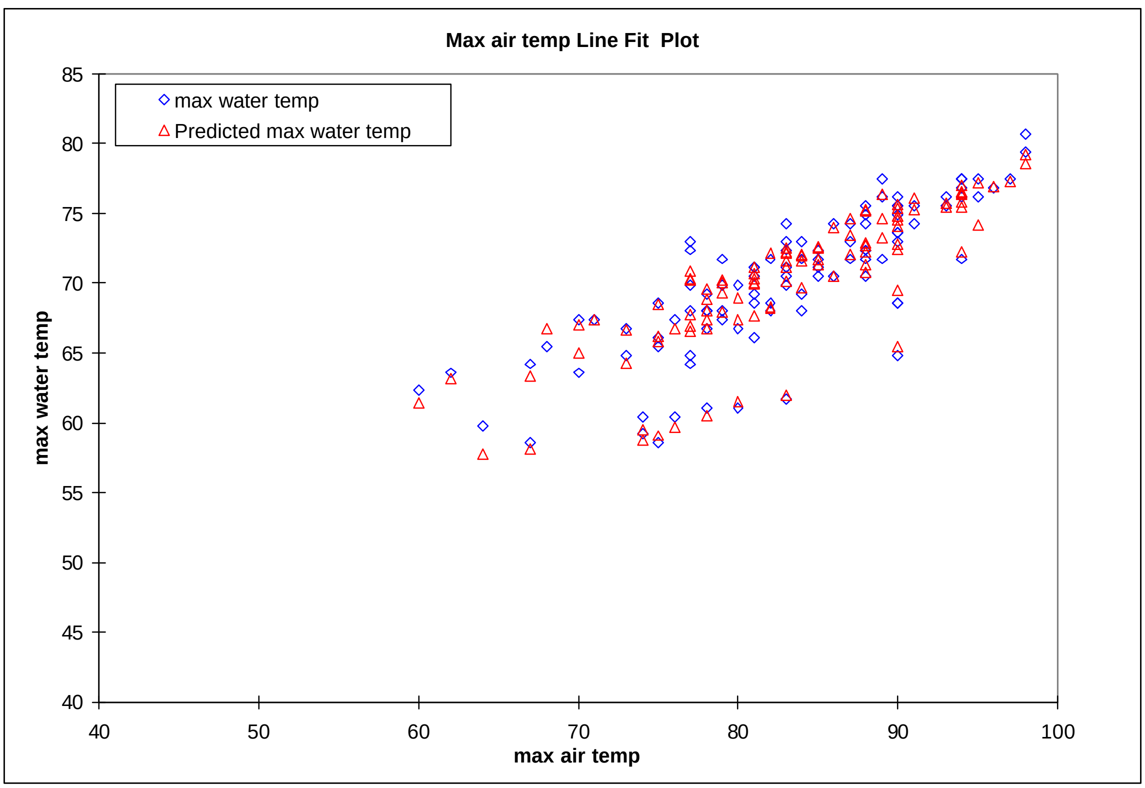


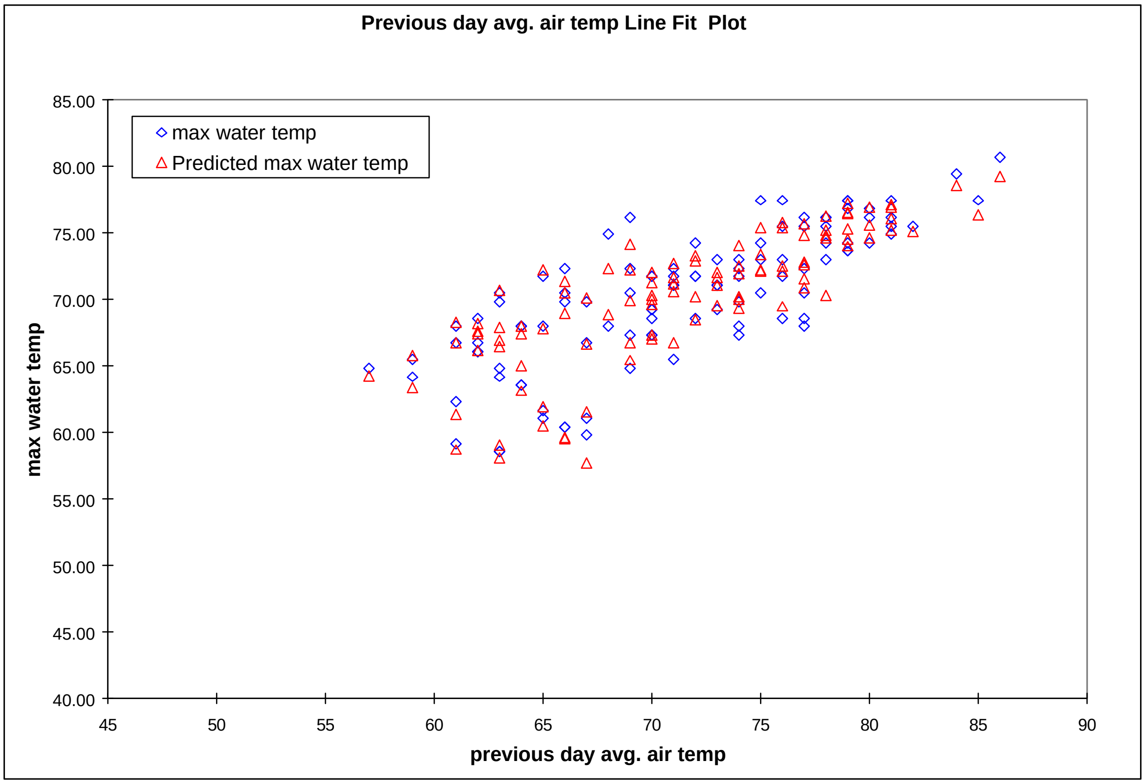

Pequannock River at Macopin
Flow vs. Date
Flow (cfs)
0
2
4
6
8
10
12
14
16
18
20
4/30/1999
5/20/1999
6/9/1999
6/29/1999
7/19/1999
8/8/1999
8/28/1999
9/17/1999
Date

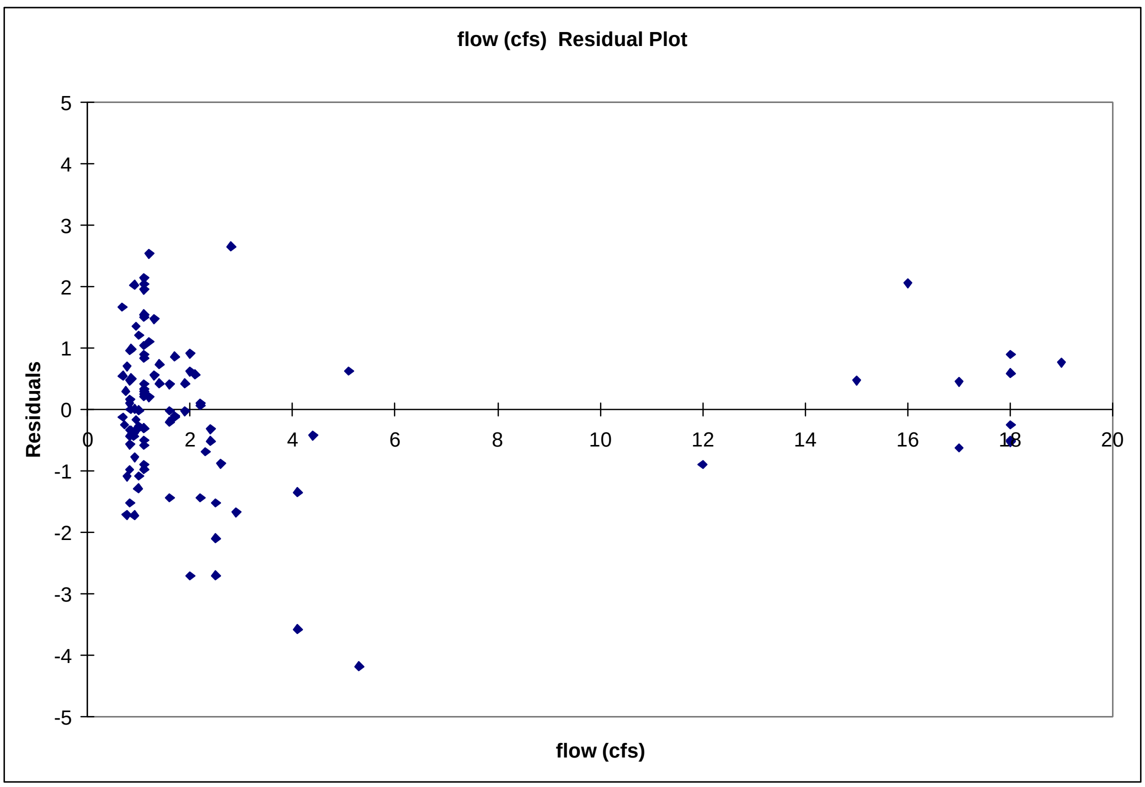

Pequannock River Watershed
Max air temperature vs. Date
Maximum air temperature
0
20
40
60
80
100
120
4/30/1999
5/20/1999
6/9/1999
6/29/1999
7/19/1999
8/8/1999
8/28/1999
9/17/1999
Date

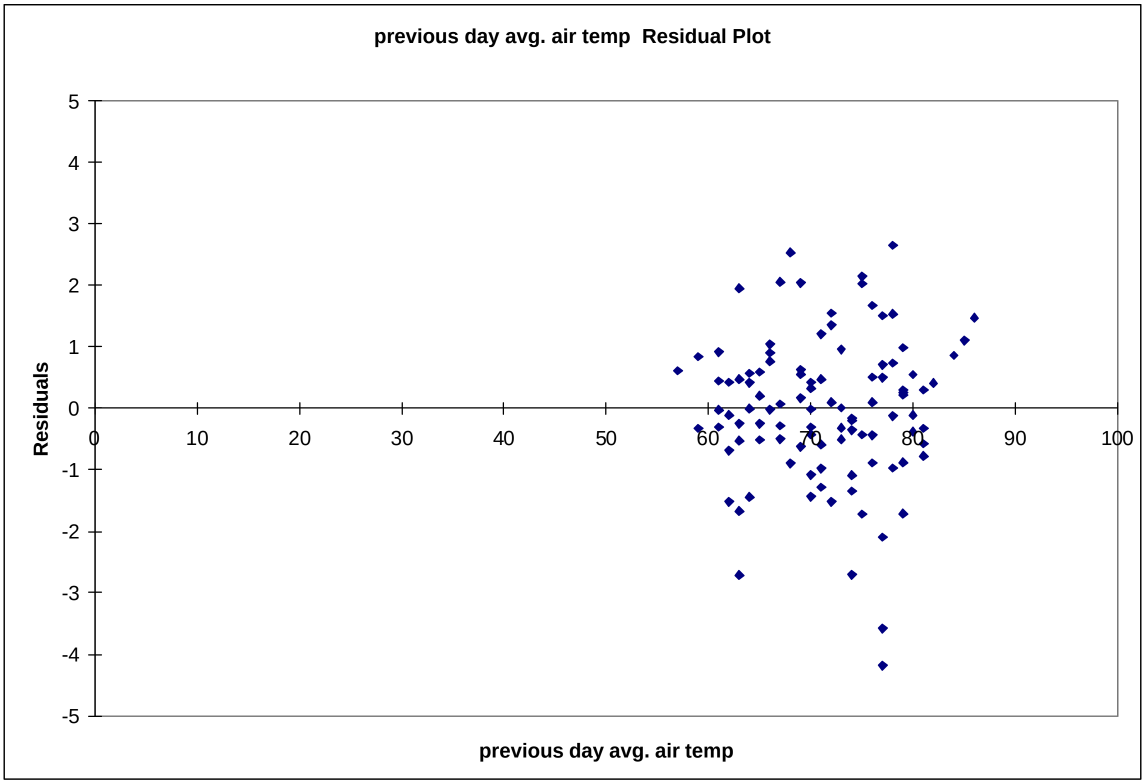
The graphs below are the output of the regression analysis. The line fit plots show that predictability of the model is very strong; this was expected based on the high value of R- square.

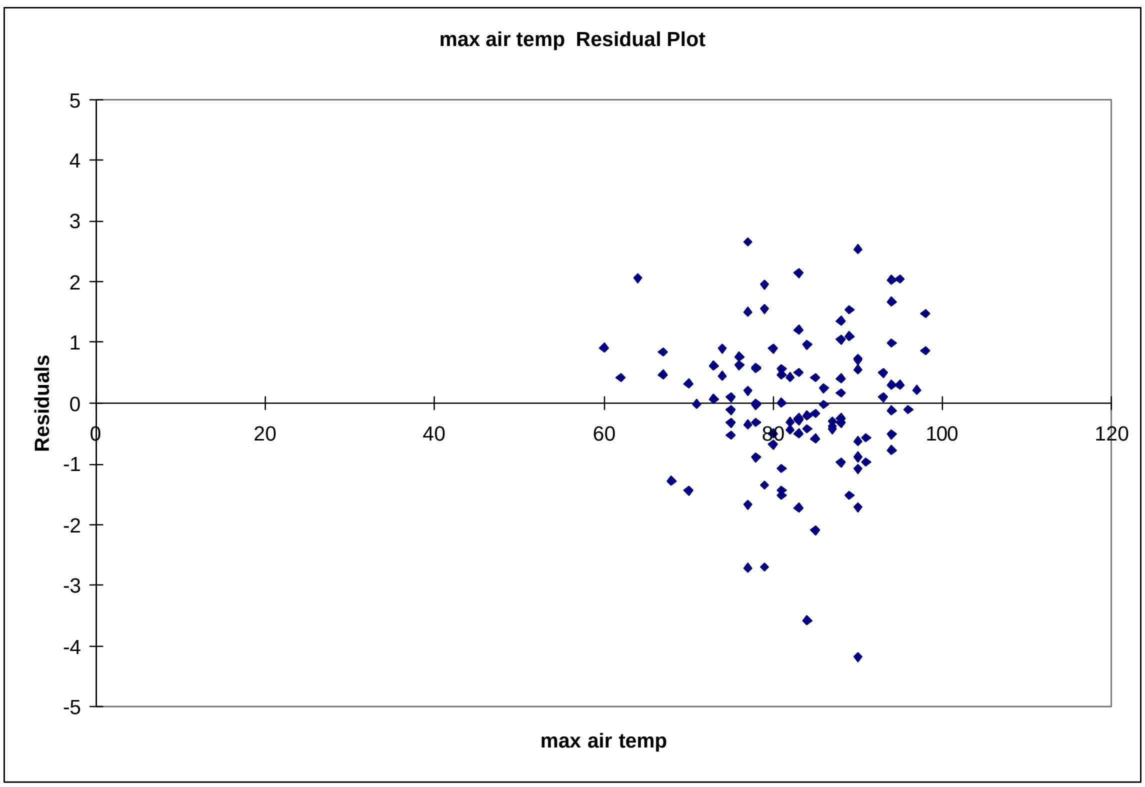





Previous day avg. air temp Line Fit Plot
max water temp
Predicted max water temp
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
45
50
55
60
65
70
75
80
85
90
previous day avg. air temp


flow (cfs) Residual Plot
Residuals
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
2
4
6
8
10
12
14
16
18
20
flow (cfs)


previous day avg. air temp Residual Plot
Residuals
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
10
20
30
40
50
60
70
80
90
100
previous day avg. air temp


max air temp Residual Plot
Residuals
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
20
40
60
80
100
120
max air temp

Computational Model Approach:

Flow and temperature data show a strong correlation between minimum passing flow and the occurrence of maximum water temperature exceeding the threshold of 68 degree Fahrenheit. The graph below shows that, as the flow increases, the occurrence of high water temperature tends to decrease, and the decrease is exponential up to a flow of about 10 cfs.

In 1907, the State and General Assembly of the State of New Jersey created the State Water Supply Commission, and established the conditions under which waters of the State may be diverted (Laws, Session of 1907, Chapter 252). Within these conditions was a requirement for fees, payable to the State of New Jersey, for water diversions. The diversion rates were determined based the amount of water which remained in the stream and was allowed to flow downstream from the point of diversion.

As described in this legislation, the minimum flow downstream of the diversion could either be based on actual records (equal to the average daily flow for the driest month), or could be calculated using a standard figure applied to the watershed in question. In order to calculate the anticipated flow downstream of the diversion, a flow rate of 125,000 gallons per day (.125 MGD) was multiplied by the square mileage of the watershed upstream from that diversion.

Using this method, a flow of 12.3 cfs has been historically used as the minimum flow for the Pequannock Watershed below the Macopin Reservoir, which is where the City of Newark Reservoir System terminates. Although the Macopin Reservoir was decommissioned in the early 1960's, the 12.3 cfs continues to apply in the current permit.

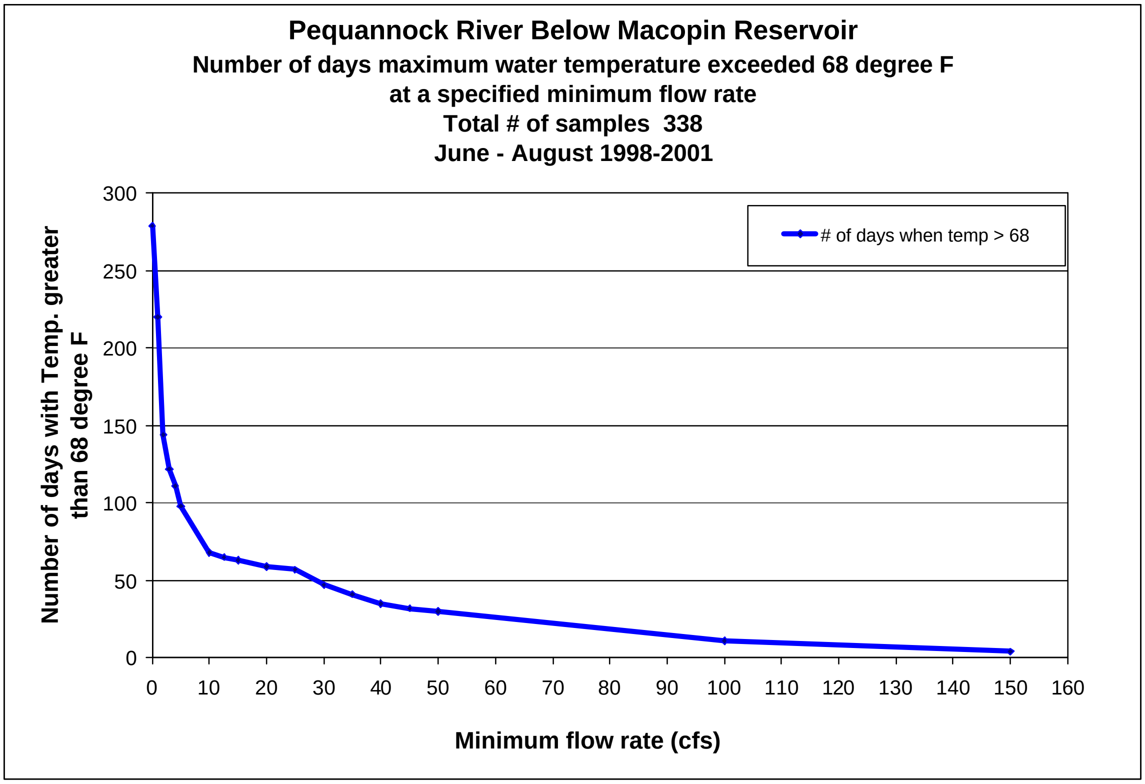
The calculation is as follows:

The Pequannock watershed is a total of 63.7 sq miles.

(63.7 sq miles) (.125 MGD) = 7.96 MGD

(7.96 MGD) (1.55)* = 12.3 cfs

* standard conversion factor for converting MGD to cfs.



Minimum flow rate (cfs)	No min. flow	1	2	3	4	5	10	12.3	15	20	25	30	35	40	45	50	100	150
Number of days when temp > 68	279	220	144	122	111	98	68	65	63	59	57	47	41	35	32	30	11	4
Percent of violations based on the entire record 338 days	83%	65%	43%	36%	33%	29%	20%	19%	19%	17%	17%	14%	12%	10%	9%	9%	3%	1%
Percent reduction from total # of violations	0%	21%	48%	56%	60%	65%	76%	77%	77%	79%	80%	83%	85%	87%	89%	89%	96%	99%

The above graph and table illustrate the number of exceedances of the 68° F criterion at various minimum passing flows, also the percent of days in violation of the standard and the estimated percent reduction based on the total number of violations. Exceedances above the 68° F criterion decrease at a significant rate between minimum flows of 0.1 and about 10 cfs; at flow rates higher than 10 cfs the decrease approaches a constant rate. When no minimum flow is set, a total number of 279 violations occurred. At a minimum stream flow of 12.3 cfs, the number of violations is reduced to 65, a 77% reduction is achieved; with a minimum flow of 20 cfs, a 79% reduction is achieved. Also, the graph shows that a close to constant reduction occurs between the minimum flows of 10 and 25 cfs. Since the percent reduction of the number of violations do not improve significantly at flow higher than 10 cfs, a flow of 12.3 cfs will be adopted as the minimum passing flow at Macopin gaging station because passing flows above this level do not produce significant improvements and 12.3 cfs has historical relevance.

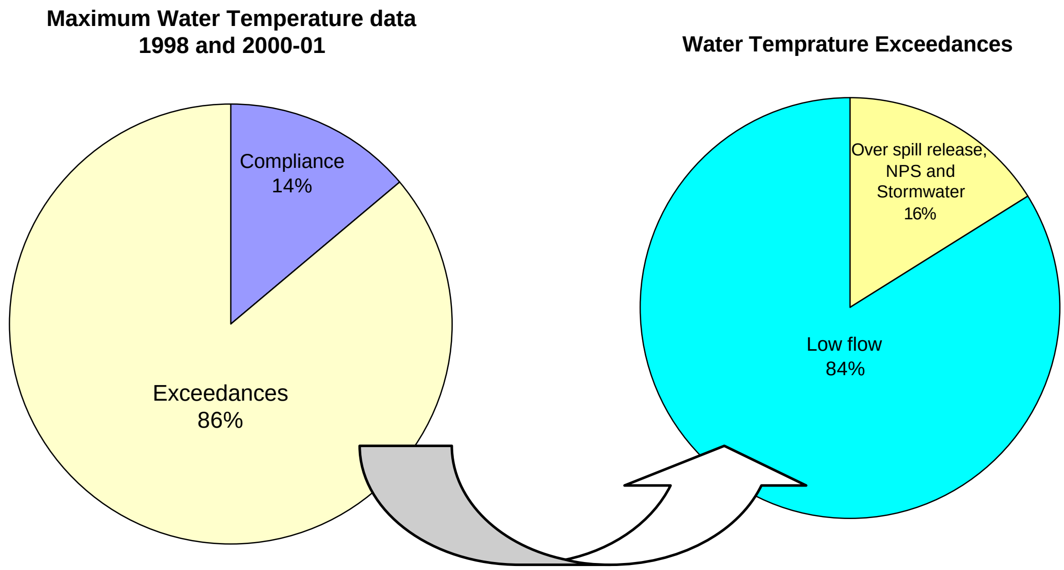
Seasonal Variation, Critical Conditions and MOS

A TMDL must account for critical conditions and seasonal variations. To address critical conditions and seasonal variation, the analysis was based on the most critical condition in the period of record and considers data from May to October, the critical season of each year.

All TMDLs must include a margin of safety to deal with uncertainty. The MOS can be implicitly incorporated through the use of conservative assumptions or explicitly specified. For these TMDLs, a MOS is included through the operating plan for reservoir releases that will be required to be developed as part of the implementation plan through the water allocation permit. The City of Newark's Water Allocation Permit No. 5123 was renewed in 2004. As a condition of the permit, Newark is required to submit an operating plan for Departmental approval describing how they plan to study the feasibility of maintaining a stream temperature of less than 68º F from May 1st to October 1st of each year. Among other things, the operating plan must contain a description, including rule curves or operating rules, of how the City of Newark proposes to regulate stream temperature without impacting safe yield and a rationale for why the approach can be expected to achieve the goal of maintaining stream temperature less then 68º F and, also a description of how the City of Newark proposes to operate the system such that the stream temperature is regulated on a seven-days-per-week basis with an alert temperature of 65º F that will trigger action to ensure temperature does not exceed 68º F. The alert temperature of 65º F will serve as an implicit margin of safety ensuring that temperature exceedances due management of reservoir manipulation is avoided.

Allocation of Load

The relative responsibility of the key sources in causing temperature violations was estimated. Responsibility for reducing violations is then distributed among the sources as the allocation of load. The degree to which low flow was responsible for violations was first estimated. In 1999, 72% of the stream temperature data exceeded the temperature criterion. 1999 represented a particularly dry year when there were no releases or overspill at the Charlotteburg dam. To account for runoff effects, rainfall events were considered. In 1999 precipitation was sparse; only 8 out of the 104 days for which there is stream temperature data had rainfall greater than 0.25 inch/day. On only 4 of those days (50%), was the stream temperature criterion exceeded. There were 14 days in which rainfall was greater than 0.1 inch/day, the minimum amount of rainfall likely to create runoff. Of those days, 6 (42%) exceeded the temperature criterion. It is reasonable then, to assign 72% of the violations to the low flow source of temperature violations. To assess the percent contribution of other sources, nondrought years 1998, 2000 and 2001 were selected. In these years, 86% of the data exceeded the stream temperature criterion. In these years, violations would be attributed to all sources: low flow, NPS, stormwater, and overspill release. The difference, 86% -72% or 14% of the temperature exceedances, is attributed to overspill release, NPS, and stormwater sources.



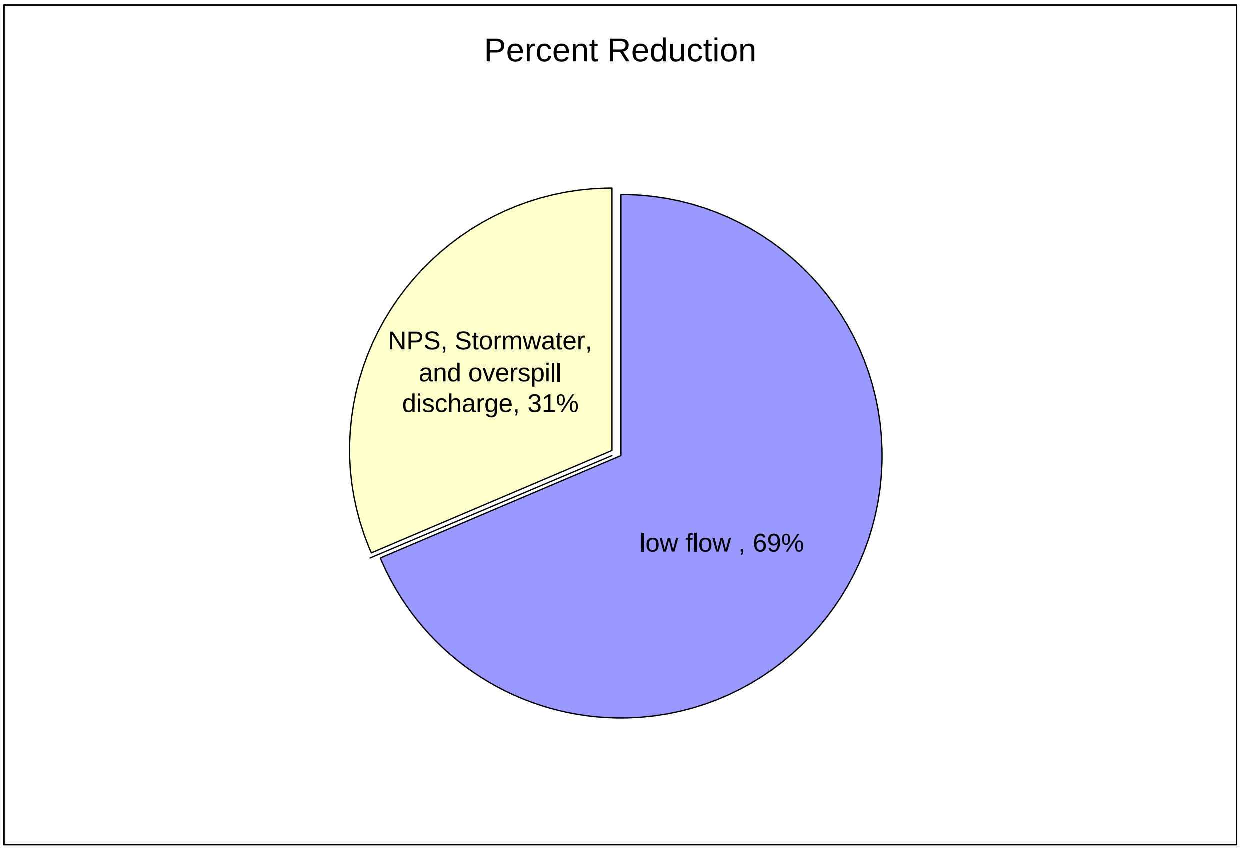
The above graphs illustrate the percent exceedances observed, and the distribution of the percent exceedances among sources: low flow, NPS, Stormwater, and from overspill release. It is concluded that 84% of the exceedances are caused by low flow, NPS, and Stormwater, where 16% of exceedances are caused by over spill release, NPS and Stormwater.

Using the minimum passing flow of 12.3 cfs, the percent reduction of the number of temperature violations based on the computational model is 77%. This percent reduction applies to all contributing sources of temperature impairment.

Using only 1999 data, the minimum passing flow requirement to comply with water temperature criterion is 17.9 cfs (using equation 2 with maximum air temperature of 90 °F and previous day air temperature of 75 °F - these values are based on the most probable temperature at which exceedances occur).

Based on the regression equation, the minimum passing flow of 17.9 cfs will reduce the temperature exceedance caused by mainly low flow by 100%. Using the same relationship, the selected minimum passing flow of 12.3 cfs will achieve a 69% reduction.

Therefore, setting a minimum passing flow of 12.3 cfs will achieve 69% reduction of violation due to low flow. The residual 31% reduction must be obtained through application of management measures to all other sources: NPS, Stormwater, and overspill release, as depicted in the following graph.



In order to achieve the percent reduction in violations assigned to reservoir effects, both minimum flow requirements and a Reservoir Release Management Program will be needed. The first task is to establish a weather dependent flow requirement for the summer months; this approach will avoid unnecessary flow releases, recognizing the multiple demands on the water resource. Second, a Reservoir Release Management Program will be required to be developed with a specified performance standard. Simply stated, water temperature should not exceed 68 degrees F or a temperature deviation of more than 1 degree Fahrenheit from the ambient temperature, absent reservoir effects, downstream from any reservoir outlet. This will require balancing the volume of spill water with cooler bottom releases as needed. A temperature probe will be installed at an appropriate distance from each reservoir outlet to provide feedback to ensure that the right mixture of top and bottom reservoir waters have been released to comply with the temperature criteria at the monitoring locations.

9.0 Implementation Plan

Management Strategies

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint and stormwater sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint and stormwater source pollution control practices, technologies, processes, citing criteria, operating methods, or other alternatives" (USEPA, 1993). A combination of best management practices and direct remedies of sources will be used to implement these TMDLs. Several overall approaches to addressing nonpoint source impairment from stormwater and deficient riparian vegetation are discussed below, followed by specific planned and ongoing short-term and long-term management strategies.

Regulatory Measures

On February 2, 2004 the Department promulgated two sets of stormwater rules: The Phase II New Jersey Pollutant Discharge Elimination System (NJPDES) Stormwater Rules, N.J.A.C. 7:12A and the Stormwater Management Rules, N.J.A.C. 7:8

<u>Phase II Stormwater Permit Rules</u>

The Phase II NJPDES Stormwater rules require municipalities, counties, highway systems, and large public complexes to develop stormwater management programs consistent with the NJPDES permit requirements. The stormwater discharged through "municipal separate storm sewer systems" (MS4s) will be regulated under the Department's Phase II NJPDES stormwater rules. Under these rules and associated general permits, the municipalities (and various county, State, and other agencies) in the Pequannock River Watershed will be required to implement various control measures that should substantially reduce phosphorus loadings. These control measures include adoption and enforcement of pet waste disposal ordinances, prohibiting the feeding of unconfined wildlife on public property, cleaning catch basins, performing good housekeeping at maintenance yards, and providing related public education and employee training. The basic requirements will provide for a measure of load reduction from existing development. Follow up monitoring may determine that additional measures are required, which would then be incorporated into Phase II permits. Additional measures that may be considered include, for example, more frequent street sweeping and inlet cleaning, or retrofit of stormwater management facilities to include nutrient removal.

Stormwater Management Rules

The Stormwater Management Rules have been updated for the first time since their original adoption in 1983. These rules establish statewide minimum standards for stormwater management in new development, and the ability to analyze and establish region-specific performance standards targeted to the impairments and other stormwater runoff related issues within a particular drainage basin through regional stormwater management plans. The Stormwater Management rules are currently implemented through the Residential Site Improvement Standards (RSIS) and the Department’s Land Use Regulation Program (LURP) in the review of permits such as freshwater wetlands, stream encroachment, CAFRA, and Waterfront Development.

The Stormwater Management Rules focus on the prevention and minimization of stormwater runoff and pollutants in the management of stormwater. The rules require every project to evaluate methods to prevent pollutants from becoming available to stormwater runoff and to design the project to minimize runoff impacts from new development through better site design, also known as low impact development. Some of the issues that are required to be assessed for the site are the maintenance of existing vegetation, minimizing and disconnecting impervious surfaces, and pollution prevention techniques. In addition, performance standards are established to address existing groundwater that contributes to baseflow and aquifers, to prevent increases to flooding and erosion, and to provide water quality treatment through stormwater management measures for TSS and nutrients.

As part of the requirement under the NJPDES Phase II program, Tier A municipalities are required to adopt and implement municipal stormwater management plans and stormwater control ordinances consistent with the requirements of the stormwater management rules. As such, in addition to changes in the design of projects regulated through the RSIS and LURP, municipalities will also be updating their regulatory requirements to provide the additional protections in the stormwater management rules within approximately two years of the issuance of the NJPDES General Permit Authorization.

Furthermore, the New Jersey Stormwater Management rules establish a 300-foot special water resource protection area (SWRPA) around Category One (C1) waterbodies and their intermittent and perennial tributaries, within the HUC14 subwatershed. In the SWRPA, new development is typically limited to existing disturbed areas to maintain the integrity of the C1 waterbody. C1 waters receive the highest form of water quality protection in the state, which prohibits any measurable deterioration in the existing water quality. A map and table listing C1 waterbodies is provided under long-term management measures.

These rules will provide protection with respect to new development in the watershed.

Although only 2 percent of the watershed is attributed to agricultural land use, various best management practices that address agricultural activities may result in temperature reductions. Implementation of conservation management plans and best management practices are the best means of controlling agricultural sources of nonpoint source pollution. Several programs are available to assist farmers in the development and implementation of conservation management plans and best management practices. The Natural Resource Conservation Service is the primary source of assistance for landowners in the development of resource management pertaining to soil conservation, water quality improvement, wildlife habitat enhancement, and irrigation water management. The USDA Farm Services Agency performs most of the funding assistance. All agricultural technical assistance is coordinated through the locally led Soil Conservation Districts. The funding programs include:

- **The Environmental Quality Incentive Program (EQIP)** is designed to provide technical, financial, and educational assistance to farmers/producers for conservation practices that address natural resource concerns, such as water quality. Practices under this program include integrated crop management, grazing land management, well sealing, erosion control systems, agri-chemical handling facilities, vegetative filter strips/riparian buffers, animal waste management facilities and irrigation systems.

- **The Conservation Reserve Program (CRP)** is designed to provide technical and financial assistance to farmers/producers to address the agricultural impacts on water quality and to maintain and improve wildlife habitat. CRP practices include the establishment of filter strips, riparian buffers and permanent wildlife habitats. This program provides the basis for the Conservation Reserve Enhancement Program (CREP).

- **Conservation Reserve Enhancement Program (CREP)** The New Jersey Departments of Environmental Protection and Agriculture, in partnership with the Farm Service Agency and Natural Resources Conservation Service, signed a $100 million CREP agreement earlier this year. This program matches $23 million of State money with $77 million from the Commodity Credit Corp. within USDA. Through CREP, financial incentives are offered for agricultural landowners to voluntarily implement conservation practices on agricultural lands. NJ CREP will be part of the USDA's Conservation Reserve Program (CRP). There will be a ten-year enrollment period, with CREP leases ranging between 10-15 years. The State intends to augment this program to make these leases permanent easements. The enrollment of farmland into CREP in New Jersey is expected to improve stream health through the installation of water quality conservation practices on New Jersey farmland.

Segment Specific Assessment and Management Measures

Short-Term Management Measures

Short term management strategies include existing projects dubbed "Action Now" that are on the ground projects funded by the Department to address temperature and other NPS impairments to an impaired waterbody. These projects include streambank restoration and beaver dam removal. Funding sources include Clean Water Act 319(h) NPS funds and other state sources. Since 1998, 319(h) funds have provided approximately 3 million annually to the Department of which approximately 1 million passed through annually in the form of grants. Priority is given to funding projects that address TMDL implementation, development of Stormwater management plans and projects that address impairment based on sublist 5 listed waterbodies.

The following short-term measures are either ongoing or are anticipated to be implemented within one year of the establishment of this TMDL. These actions will have an immediate and positive effect on overall temperature reduction and maintenance. The projects are as follows:

- A federally funded, state approved 319(h) grant project, *Pequannock River Thermal Mitigation* is underway in the Pequannock River Basin. This grant includes several components for different areas of the Pequannock River Watershed. In the Upper Pequannock River Watershed one factor that leads to elevated temperatures is impoundment of flows and removal of shading tree canopy by beaver colonies along the Pequannock River and tributaries. As the beaver colonies migrate they leave abandoned dams behind. Also the past flooding of the area has altered extensive land areas creating meadows where forested areas were located.

  A survey of the upper Pequannock River is in the process of being conducted to determine the extent and location of beaver dams, ponds and tree removal and to provide information for future restoration and mitigation projects. The survey will include GIS maps, GPS coordinates, digital photographs and field notes. A component of the upper watershed survey will be the installation of willow and red-osier dogwood cuttings to help re-establish the riparian tree canopy.

  This grant will also fund a temperature and flow study for 11 significant tributaries to the lower Pequannock for the comparison with the mainstem Pequannock to determine the influence of these tributaries on the Pequannock.

Some may exert a positive (cooling) influence while others may exert a negative (warming) influence dependant upon the mainstem. GPS mapping of stormwater outfalls will be conducted as stormwater discharges typically have elevated temperatures. This mapping will provide background data for possible stormwater mitigation projects.

- A *WMA 3 Restoration Master Plan* was conducted over two years using a visual assessment protocol modified from the USDA methodology. This project was also funded with 319h funding. This project included four sub-watersheds, one of which was the Pequannock. Forty-five sites in the Pequannock Basin were identified for restoration projects. The average score based on the visual assessment for the overall basin was 7.8 SVAP (STREAM VISUAL ASSESSMENT PROTOCOL). Of the 45 sites, 24 scored below the basin average scores. Several of the Pequannock sites were rated as high priority and these sites would be priority sites for future restoration projects. Although the SVAP did not look specifically at temperature impairments, streambank restoration with replacement canopy would have a mitigating effect on temperature exceedances. An addendum of the final report included a Management Strategy Table with a Habitat Enhancement category. For this category several sites on the Pequannock River and Kanouse Brook have been identified as candidates for habitat restoration and enhancement.

- Another 319(h) funded project is the, *Pequannock River Renaturalization of Channelized Flow at Route 23*. This site is downstream of the Oak Ridge Reservoir and just upstream of the confluence with Clinton Brook. At this point the river is 63 feet wide, straight and the bed is lined with concrete. This project was completed due to the expansion of Route 23, and in order to accomplish this expansion it was necessary to move the Pequannock River from its original channel. The wide channel leads to shallow flow and loss of canopy cover, both of which lead to elevated temperatures. At this point in the river the physical constraints are thought to be a significant contributing factor to the temperature impairment. The project will provide construction of a semi-shaded low flow channel within the existing channel using earthen and biological materials. The low flow channel will be constructed to include meanders, point bars and deltas. The newly formed streambanks will be stabilized using fascines, coconut fibers and other appropriate materials. Native trees and shrubs will be planted to help provide canopy.

- The Department has identified the Pequannock River from the outlet of Macopin Reservoir to the Borough of Butler municipal border as the WMA 3 priority stream segment. Funding is provided by the Corporate Business Tax for an in-depth study of the sources of thermal impairment and other nonpoint source impairments. The final deliverable for this project will be an in-depth site specific implementation plan, with associated costs and prioritized projects. This study will be completed by January 2005, and the follow-up associated project will be implementation of the prioritized projects.

Long-term Management Strategies

While short-term management measures such as the *Pequannock River Thermal Mitigation Project*, the Prioritized stream segment implementation plan and the *WMA 3 Restoration Master Plan* will help provide an implementation prioritized list for further projects to help alleviate nonpoint source thermal degradation, additional measures will be needed to verify and further reduce or eliminate these sources. Some of these measures will be implemented now, where resources are available and sources have been identified as causing the impairment. Both short-term and long-term management strategies that address temperature mitigation related to the identified sources may be eligible for future Department funding.

Streambank Restoration

The loss of riparian canopy, leading to an increased "view to the sky" along the lower portion of the Pequannock River should be quantitatively documented preferably by GIS analysis including indications of which areas could have canopy restored. The effects of tributaries on stream temperature should be further studied.

As part of the WMA 3 Restoration Master Plan the following sites were identified with a loss of canopy and/or vegetated riparian corridors and these sites can provide a starting point for addressing riparian corridor restoration on both the main stem Pequannock and significant tributaries feeding the river.

- Site 142- Pequannock River northwest of Route 23between old Route 23 and Route 23 Railroad
- Site 143- Pequannock River southwest tributary of Pequannock headwater at Rt. 23 bridge crossing
- Site 153- Clinton Brook 0.25 miles above Clinton Reservoir
- Site 155- Kanouse Brook, 0.65 miles north of confluence with Pequannock River
- Site 156- Kanouse Brook, 2.2 miles north of confluence with Pequannock River
- Site 158- Clinton Brook, 1.1 miles south of Clinton Reservoir adjacent to LaRue Road
- Site 168- Stone House Brook at confluence with Pequannock River
- Site 172- Pequannock River, 0.8 miles north of confluence with Wanaque
- Site 174- Matthew Brook
- Site 176- Van Dam Brook, Riverdale Town Park
- Site 177- Pequannock River, 0.15 mles north of confluence of Beaver Brook

This list should not be considered inclusive as it was part of a larger project of which thermal mitigation was not the primary focus, therefore the list should be considered a starting point. The study also looked at ownership of land, and had public lands as a criterion for evaluation. As redevelopment occurs inclusion of a riparian corridor to provide canopy should also be considered. There may be instances where the breaching of minor impoundments would be a beneficial activity for the stream ecology.

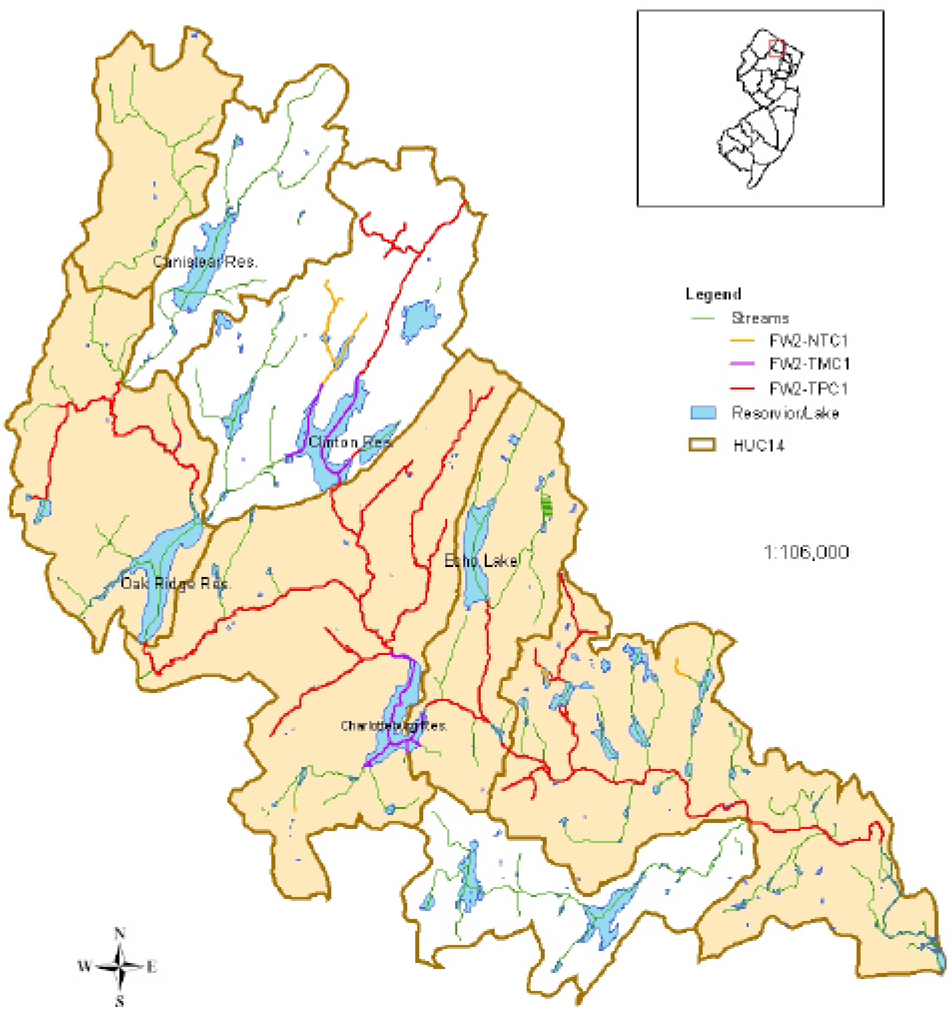
Category One Designation

The Department has designated a special level of protection for a number of waterways in New Jersey. This protection, known as C1, targets waterbodies that provide drinking water, habitat for Endangered and Threatened species, and popular recreational and / or commercial species, such as trout or shellfish. Waterways can be designated C1 because of exceptional ecological significance, exceptional water supply significance, exceptional recreational significance, exceptional shellfish resource, or exceptional fisheries resource. The C1 designation provides additional protections to waterbodies that help prevent water quality degradation and discourage development where it would impair or destroy natural resources and environmental quality. The stormwater rules emphasizing ground water recharge and special buffer-area protections for C1 waterbodies. In addition to moving forward with individual rulemaking on C1 designations, the Department issued a preliminary list of candidate water bodies statewide for consideration. The Department also invited the public to nominate waters they believed qualified for C1 protection, and this information was used by the Department in adopting additional candidates for C1 designation.

The following table is comprehensive to the entire Pequannock River Watershed and was taken from the November 2003 SWQS 7:9B.

Waterbody	Classification
Apshawa Brook (Macopin) – Entire Length	FW2-TP(C1)
Charlotteburg Reservoir (Charlotteburg)	FW2-TM(C1)
Clinton Brook (W. Milford) Clinton Reservoir dam to Pequannock River	FW2-TP(C1)
Clinton Reservoir (W. Milford)	FW2-TM(C1)
Macopin River (New Foundland) Echo Lake dam downstream to Pequannock R	FW2-TP(C1)
Mossmans Brook (West Milford) Source to confluence with Clinton Reservoir	FW2-TP(C1)
Pequannock River Mainstem:	
(Hardyston) - River and the easterly tributary from Pacock Brook to, but not including, Oak Ridge Reservoir	FW2-TP(C1)
(New Foundland) – Outlet of Oak ridge Reservoir downstream to, but not including Charlotteburg Reservoir	FW2-TP(C1)
(Charlotteburg) – Outlet of Charlotteburg reservoir to, but not including, Macopin Reservoir or the Green Pond Junction tributary	FW2-TP(C1)
(Kinnelon) - Macopin Reservoir outlet to Hamburg Turnpike bridge in Pompton Lakes Borough	FW2-TP(C1)

Map of C1 designated waterbodies within the impaired segments



Additional Modeling

One approach that may be used to simulate the temperature in the stream is to model the entire river system including the reservoirs. The problem with this approach is the insufficient data available (e.g. reservoir flow, geometry, stream flows and temperatures). A second approach is to focus only on the impaired segments rather than the entire river without compromising accuracy. By running the model under different hydrological variables, we will be able to estimate the flow at which the temperature criteria will be violated. Stream Segment Temperature Model (SSTEMP) will be used to predict the temperature in each impaired segment. The basic equations and mechanics governing this model are identical to those in the full version model, Stream Network Temperature Model (SNTEMP), except that SSTEMP model can only simulate temperature in a single segment.

A brief summary of input data required to run this model may include the following:

- Hydrological variables (e.g. flow and temperature data)
- Geometry variables (e.g. Latitude, segment length, elevation, segment width, cross section area, Manning's number, width versus flow data)
- Time of the year
- Meteorological data (e.g. air temperature, ground temperature, relative humidity, wind speed, thermal gradient, possible sun %, dust coefficient
- Shade variable (e.g. Segment Azimuth, topographic altitude, vegetations height, density, and offset)

Description of Logic [1]
'In general terms, SSTEMP calculates the heat gained or lost from a parcel of water as it passes through a stream segment. This is accomplished by simulating the various heat flux processes that determine that temperature change. These physical processes include convection, conduction, evaporation, as well as heat to or from the air (long wave radiation), direct solar radiation (short wave), and radiation back from the water. SSTEMP first calculates the solar radiation and how much is intercepted by (optional) shading. This is followed by calculations of the remaining heat flux components for the stream segment. The details are just that: To calculate solar radiation, SSTEMP computes the radiation at the outer edge of the earth's atmosphere. This radiation is passed through the attenuating effects of the atmosphere and finally reflects off the water's surface depending on the angle of the sun. For shading, SSTEMP computes the day length for the level plain case, i.e., as if there were no local topographic influence. Next, sunrise and sunset times are computed by factoring in local east and Westside topography. Thus, the local topography results in a percentage decrease in the level plain daylight hours. From this local sunrise/sunset, the program computes the percentage of light that is filtered out by the riparian vegetation. This filtering is the result of the size, position and density of the shadow-casting vegetation on both sides of the stream.' (Stream Segment Temperature Model (SSTEMP) Version 2.0 Revised August 2002, by John Bartholow, USGS)

Ecological Flow Goals
Over the past couple of years, staff from the Department and USGS have met to conduct a research project aimed at examining flow characteristics and basis for developing ecological flow goals for New Jersey streams. One main goal of the study is to develop methodologies appropriate to New Jersey to calculate stream flows needed to protect

aquatic communities such as: fish, aquatic invertebrates, endangered and threatened species. A preliminary report is expected in 2005.

Small Impoundments

Although discharges from large reservoirs are a major contributing factor to the temperature elevation in the Pequannock River, discharges into river tributaries from a number of smaller lakes and ponds can also contribute to thermal elevation in the Pequannock River and its tributaries. This occurs because impoundments slow flows, expose waters to increased sunlight and release heated surface water from impoundments over spillway outlets. The Pequannock River Coalition has determined that this problem is most extensive in the lower Pequannock drainage from Macopin to Riverdale. Of the 14 tributaries in this river segment, 10 (71%) have impoundments. Under one of the previously mentioned 319(h) nonpoint source projects, the Pequannock River Coalition is assessing the precise nature of flows and temperatures in these tributaries. Preliminary sampling has shown that small impoundments do offer a level of temperature stratification within these impoundments that may be utilized to achieve downstream temperature reductions of 3-4 degrees Fahrenheit.

Additional Measures

- The placement of a USGS gaging station below Oakridge Reservoir appears warranted
- Identify stormwater outfalls that specifically contribute to elevated water temperatures and determine applicable strategies to address
- Develop a regional stormwater management plan in addition to the required municipal stormwater management plans
- Install multi-depth temperature gages in both Oakridge and Charlottesburg Reservoirs.

Water Allocation Permit Requirements

A Memorandum of Understanding (MOU) presently exists with the City of Newark and the Department to not let temperatures exceed 75°F and to maintain a Minimum Passing Flow of 5 cfs below the Oakridge Reservoir. While this has proven effective in preventing major fish kills in some instances, multiple studies indicate that temperatures above 68-70°F causes stress in native trout species, and may impede reproduction and overall population health. Also during a drought the MOU is not in affect. As stated previously, the SWQS regulates a minimum of 68°F for trout maintenance waterways. In addition, releasing 5 cfs at the 75°F threshold is not always effective due to time-lags between notification and response, i.e., the City of Newark facilities are closed evenings and weekends—a “buffer” of an additional 3°F is therefore warranted. Subsequently, the City of Newark’s water allocation was renewed in 2004 to include a specific condition to replace the MOU with a new temperature threshold of 65°F to both conform to the SWQS as well as provide a sufficient buffer to protect against criteria exceedances. An operating plan describing how they plan to study the feasibility of maintaining a stream temperature less than 68°F from May 1st to October 1st of each year will be a permit requirement. In addition, the minimum passing flow of 12.3 cfs below Macopin will be reinstated in the present water allocation permit. The safe yield of the system must also be updated and verified based on the drought of 2002. The operation plan must also provide a strategy for regulating stream temperatures to 65° F without impacting safe yield. Coordination with City of Newark is necessary to create and adopt a comprehensive “release regime” that will achieve multiple objectives.

Implement Beaver Management Strategy

The Department’s Division of Fish and Wildlife has been involved in beaver management and control in Newark’s Pequannock River Watershed for a number of years. Much of the effort was initiated by complaints from Newark’s Superintendent of Water Supply due to his assertion that beaver dams were impeding the flow of water between reservoirs. The Division’s involvement has included trapping by division personnel, directing trappers to the watershed area during the trapping season, and issuing depredation permits in emergency situations. In coordination with City of Newark, a comprehensive annual Beaver Management Strategy Plan needs to be developed to reduce overall beaver populations and subsequently the number of beaver dams and ponds within the watershed, particularly along the upper Pequannock River headwaters, Pacack Brook and Clinton Brook. This objective can be approached in the following manner:

a) The Pequannock River Coalition in cooperation with Newark Water Supply will conduct surveys in late October to identify problem areas and beaver wintering colonies.

    - Personnel criteria for each entity must be established so that complete areas may be ground-truthed efficiently.
    - Comprehensive maps will be necessary to record activity locations.
    - Authorization may be necessary on lands not owned by City of Newark or the State.

b) Upon submission of the list of identified problem areas the Division of Fish and Wildlife will direct trappers to these areas.

- Recreational trapping is the Division's first choice for the removal of beavers—trapping season runs January 1—February 9. There is a limit of 10 beavers per trapper

c) The Pequannock River Coalition, with assistance from Newark Water Supply, will breech beaver dams.

- Personnel criteria for each entity must be coordinated.
- Logistics of dam removals must be determined, i.e., equipment and number of personnel required, how to evaluate costs, etc.
- In some case beaver baffles or fumes may be incorporated.
- Landowners are not required to have authorization or permits to remove beaver dams.

Ongoing Program of Riparian Restoration

Forest canopy and the shading from direct sunlight is a necessary and critical component with regard to limiting temperature increases in a given waterway, particularly smaller first-order and headwater streams. Beaver activity within the Pequannock River Watershed has resulted in multiple areas of treeless meadow where once dense forest had been. In conjunction with the Beaver Management Strategy outlined above, a parallel and companion program of ongoing riparian reforestation such as that outlined below should also be implemented to revegetate these sections that have been cleared. Installing protective measures such as shoreline fencing and wire-mesh tree girdles may also be incorporated to prevent future beaver inhabitation.

a) Identify deforested problem areas.

- This can be accomplished during the October surveys for beaver activity.

b) Identify potential funding sources for individual reforestation projects, i.e., 319(h), EPA, HEP, and Watershed Management Group grants, to name several.

c) Identify entities to design and carry out projects, such as Pequannock River Coalition, City of Newark and Trout Unlimited.

d) Install preventative measures as a component of individual projects or as a comprehensive project itself.

10.0 Follow - up Monitoring

The Department's primary surface water quality monitoring program is the Bureau of Water Monitoring with the Division of Science and Research. In association with the Water Resources Division of the United States Geological Survey, the Department has cooperatively operated the Ambient Stream Monitoring Network (ASMN) in New Jersey since the 1970s. The ASMN currently includes 3 stations that are routinely monitored on a quarterly basis. Three impairments are part of this network. As stated previously, beginning with the 2002 Integrated List the Department began to accept data from other entities. This comprises the impairments from which the TMDLs are based.

The Pequannock River Coalition presently monitors 16 sites within the Pequannock River Watershed, on the mainstem and tributary locations, for both temperature and flow rates. Readings are recorded from June through October from continuous recorders set every ½ - 1 hour for 24-48 readings per day. This organization currently has 2 grant applications pending to further enhance this network with 11-16 more sites, including 3 STP outfalls, 2 stormwater outfalls, and data points on multiple tributaries just short of their confluences with the Pequannock River mainstem to determine which are contributing flows that are warmer, cooler, or neutral in temperature. The Department will also continue to monitor temperature through its Ambient Surface Water Monitoring Program.

In order to establish a baseline of current fish health and to gauge changes over time in the fish to measure the effect the management measures are having on mitigating elevated water temperature, the Department's Bureau of Fresh Water Fisheries will conduct a 5 year project to perform fish IBI. Therefore the use of trout species that are sensitive to temperature as an indicator species, would serve as an additional "tool" to measure water quality improvement over time. This project will entail electrofishing, that will be used to establish reliable population estimates, length-weight relationships, and age and growth of the trout and other fish found in the Pequannock River. Two to three sites in a specified stretch of the Pequannock River will be monitored. It is anticipated that the results from this study will verify that the implementation of both long term and short term management measures are reducing temperature impairment.

11.0 Reasonable Assurance

Reasonable assurance for the implementation of these TMDLs has been considered for both point and nonpoint sources.

With the implementation of follow-up monitoring and source identification, the Department is reasonably assured that New Jersey's Surface Water Quality Standards will be attained for temperature. Activities directed in the watersheds to reduce temperature shall include options as described in the implementation section.

12.0 Public Participation

In accordance with the Water Quality Management Planning Rules N.J.A.C. 7:15 –7 et seq., each TMDL shall be proposed by the Department as an amendment to the appropriate areawide water quality management plan(s) in accordance with N.J.A.C. 7:15-3.4(g). N.J.A.C. 7:15-3.4(g)5 states that when the Department proposes to amend the areawide plan on its own initiative, the Department shall give public notice by publication in a newspaper of general circulation in the planning area, shall send copies of the public notice to the applicable designated planning agency, if any, and may hold a public hearing or request written statements of consent as if the Department were an applicant. The public notice shall also be published in the New Jersey Register.

As part of the public participation process for the development and implementation of the TMDLs for temperature in the Northeast Water Region, the Department worked collaboratively with stakeholders in WMA 3 as part of the Department's ongoing watershed management efforts. The Department's watershed management process includes a comprehensive stakeholder process that includes members from major stakeholder groups (agricultural, business and industry, academia, county and municipal officials, commerce and industry, purveyors and dischargers, and environmental groups). As part of the watershed management planning process, Public advisory Committees (PACs) and technical Advisory Committees (TACs) were created in all 20 WMAs. The PACs serve in an advisory capacity to the department, examining and commenting on a myriad of issues in the watersheds. The TACs are focused on scientific, ecological, and engineering issues relevant to the issues of the watershed, including water quality impairments and management responses to them.

The Department shared the Department's TMDL process through various presentations and discussions with the WMA 3 TAC members. Presentations included: Introduction to TMDLs Data and Input on Source Identification for 32 Fecal TMDLs in Northeast Water Region as well as most recently presentations and discussions on the draft TMDL document and methodology where held on April 30th and May 21, 2004. In addition to the presentations, the TAC and Pequannock River Coalition have been instrumental in providing comments and suggestions to the Department during this process.

Additional input was received through Rutgers New Jersey EcoComplex (NJEC). The Department contracted with the NJEC in August 2001. The NJEC consists of a nine member review panel of New Jersey university professors whose role is to provide comments on the Department's technical approaches for the development of TMDLs and other management strategies. An overview of the Pequannock River temperature impairments was presented to the panel on December 12, 2003. Several approaches were subsequently discussed with NJEC before the present methodology was found to be acceptable to address the impairments.

Amendment Process

In accordance with N.J.A.C. 7:15-7.2(g), these TMDLs are herby proposed by the Department as an amendment to the Northeast Water Quality Management Plan (WQMP).

Notice proposing these TMDLs was published June 7, 2004 in the New Jersey Register and in newspapers of general circulation in the affected area in order to provide the public an opportunity to review the TMDLs and submit comments. In addition, a public hearing will be held July 9, 2004 at the Kinnelon Public Library. The Northeast WQMP is not overseen by a designated planning agency; therefore notice of the proposal and hearing has only been provided to affected municipalities.

EPA Region 2 will also be given notice of these TMDLs and will be asked to provide comments to the Department for consideration during the public comment period. All comments received during the public notice period and at any public hearings will become part of the record for these TMDLs. All comments will be considered in the establishment of these TMDLs and the ultimate adoption of these TMDLs, once USEPA Region 2 approves these TMDLs.

Appendix A References

Carron, John C. and Rajaram, Harihar, June 2001, Impact of Variable Reservoir Releases on Management of Downstream Water Temperatures, Water Resources Research, Vol. 37, No. 6, pages 1733-1743

Deas, Michael L. and Lowney Cindy L. September 2000, Water Temperature Modeling Review Central Valley, sponsored by the Bay Delta Modeling Forum, California Water Modeling Forum, pages 1- 113

Dong, J, Chen, J, Brosofske, K.D., and Naimans, R.J., 1998, Modelling Air Temperature Gradients Across Managed Small Streams In Western Washington, Journal of Environmental Management 53, 309-321 Article No. ev980217

Dortch, Mark S., Ph.D., P.E., Water Quality Considerations in Reservoir Management, United States Army Corp of Engineers – US Army Engineer Waterways Experiment Station, Pages 32 - 42

Georgia Department of Natural Resources Environmental Protection Division, January 2003, Chattahoochee River Temperature TMDL pages 1- 18

Graham, J.M., 1949, Some Effects of Temperature and Oxygen Pressure on the Metabolism and Activity of the Speckled Trout, Salvelinus fontinalis. Canadian Journal of Research 27: 270-288

Gu, Ruochuan, McCutchen, Steven and Chen, Chi-Jen, Development of Weather-Dependent Flow Requirements for River Temperature Control, Environmental Management Vol. 24 No. 4 pages 529-540

Julius, Susan Herod, June 15, 2001, What are the Potential Impacts of Climate Change on Fresh Water Recreational Fishing Opportunities in the U.S.? Presentation to Water Ecology and Climate Change Workshop, Global Change Research Program

Neumann, David, Rajagopalan, Balaji, and Zagona, Edith, July 2003, Regression Model for Daily Maximum Stream Temperature, Journal of Environmental Engineering ASCE, pages 667-674

New Jersey Geological Survey, 1986, The Geology of New Jersey map with descriptions

New Jersey Department of Environmental Protection, New Jersey 2002 Integrated Water Quality Monitoring and Assessment Report (305(b) and 303(d)

New Jersey Department of Environmental Protection, *draft* New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report (305(b) and 303(d)

Poole, G.C and Berman C.H. February 2002, Pathways of Human Influence on Water Temperature Dynamics in Stream Channels, Environmental Management pages 1-20

Raleigh, R.F., 1982, Habitat Suitability Index Model: Brook Trout, U.S Fish and Wildlife Service, Fort Collins, Co

Roa-Espinosa, A., Wilson, T.B., Norman, J.M and Johnson, K., 2003, Predicting the Impact of Urban Development on Steam Temperature Using a Thermal Urban Runoff Model (TURM), National Conference on Urban Stormwater: Enhancing Programs at the Local Level. Proceeding Chicago, Il. Feb 17-20, 2003. USEPA, Office of Research and Development, Technology Transfer and Support Division, Cincinnati, Ohio.

State of Idaho, Department of Environmental Quality, May 2003, South Fork Clearwater River Subbasin Assessment and TMDLs Appendix I. Overview of Stream Heating Process, Pages 1 – 12

Sinokrot, Bashara A. and Gulliver, John S., In-stream Flow Impact on River Temperatures, Journal of Hydraulic Research, Vol. 38, 2000, No. 5 pages 339-349

Stevens, Herbert H. Jr., Ficke, John F. and Smoot, George F. 2nd Printing 1978, Techniques of Water-Resources Investigations of the United States Geological Survey Chapter D1 Water Temperature-Influential Factors, Field Measurement, and Data Presentation

Thomann, Robert V. and Mueller, John A., 1987, Principles of Surface Water Quality Modeling and Control, Harper Collins Publishers Inc.

United States Fish and Wildlife Service, September 1982, Habitat Suitability Information: Brook Trout. Fish and Wildlife Service U.S. Department of the Interior

United States Fish and Wildlife Service, January 1984, Habitat Suitability Information: Rainbow Trout. Fish and Wildlife Service U.S. Department of the Interior

United States Geological Survey, Water Resource Data New Jersey Water Year 2001, Volume 1. Surface-Water Data, Water-Data Report NJ-01-1.

Wetzel, R.G., 1983 Limnology 2nd Edition CBS College Publishing, New York, NY.

Appendix B Data Sources

date	average water temp	max water temp	flow (cfs)	max air temp	previous day avg. air temp
5/20/1999	58.22	60.44	19	76	66
5/21/1999	58.64	61.06	18	80	67
5/22/1999	59.35	61.06	18	78	65
5/23/1999	59.63	59.81	16	64	67
5/24/1999	58.12	58.55	15	67	63
5/25/1999	57.27	59.18	17	74	61
5/26/1999	57.63	58.55	18	75	63
5/27/1999	58.27	60.44	18	74	66
5/28/1999	59.70	61.69	18	83	65
5/29/1999	61.88	64.84	17	90	69
5/30/1999	63.31	68.61	12	90	76
5/31/1999	63.40	68.61	5.3	90	77
6/1/1999	64.6	68.0	4.1	84	77
6/2/1999	65.9	69.2	4.4	84	70
6/3/1999	65.7	68.0	4.1	79	74
6/4/1999	63.9	67.4	5.1	76	69
6/5/1999	61.7	64.8	2.9	77	63
6/6/1999	62.5	66.1	2.5	81	62
6/7/1999	67.2	71.7	2.4	94	65
6/8/1999	69.7	73.6	2.6	90	79
6/9/1999	67.7	70.5	2.5	85	77
6/10/1999	65.0	68.6	2.2	75	72
6/11/1999	63.4	68.0	2.1	78	64
6/12/1999	61.5	64.2	2	77	63
6/13/1999	64.3	66.7	2.3	80	62
6/14/1999	65.1	67.4	2.5	79	74
6/15/1999	65.7	69.2	2.4	78	73
6/16/1999	63.2	66.7	2.2	73	67
6/17/1999	60.9	62.3	2	60	61
6/18/1999	60.9	64.8	2	73	57
6/19/1999	61.7	66.7	1.9	78	61
6/20/1999	62.2	66.1	1.7	75	62
6/21/1999	61.5	63.6	2.2	70	64
6/22/1999	63.4	68.6	1.9	82	62
6/23/1999	65.7	70.5	1.6	86	66
6/24/1999	66.6	71.7	1.4	85	70
6/25/1999	65.8	70.5	1.3	81	69
6/26/1999	69.1	74.9	1.2	90	68
6/27/1999	69.9	74.3	1.1	91	78
6/28/1999	72.0	76.2	1.1	89	78
6/29/1999	72.4	75.6	1.6	88	82
6/30/1999	69.3	73.0	2.8	77	78
7/1/1999	67.3	68.6	1.6	81	70
7/2/1999	69.5	71.7	1.6	84	74
7/3/1999	71.6	75.6	1.4	90	78
7/4/1999	72.8	76.8	1.7	96	80
7/5/1999	75.2	79.4	1.7	98	84

7/6/1999	75.9	80.7	1.3	98	86
7/7/1999	74.0	77.5	1.2	89	85
7/8/1999	69.9	74.3	1.1	83	75
7/9/1999	68.0	71.7	1.1	87	70
7/10/1999	68.9	72.4	0.94	85	74
7/11/1999	66.8	71.7	1.1	79	72
7/12/1999	64.5	68.0	1.2	77	65
7/13/1999	65.8	69.9	1.1	79	63
7/14/1999	64.4	68.0	1.1	78	68
7/15/1999	66.4	72.4	1.1	88	66
7/16/1999	70.2	76.2	1.1	95	69
7/17/1999	72.5	77.5	1.1	97	79
7/18/1999	73.1	77.5	1.1	95	81
7/19/1999	72.6	76.2	0.92	94	81
7/20/1999	71.7	74.3	0.92	87	80
7/21/1999	69.5	71.7	0.9	82	76
7/22/1999	68.8	70.5	0.91	83	75
7/23/1999	72.1	77.5	0.91	94	75
7/24/1999	72.2	75.6	0.83	91	81
7/25/1999	72.8	76.8	0.74	94	79
7/26/1999	72.3	76.2	0.69	90	80
7/27/1999	72.1	77.5	0.68	94	76
7/28/1999	71.9	76.2	0.69	94	78
7/29/1999	71.3	75.6	0.77	90	77
7/30/1999	71.6	75.6	0.82	93	76
7/31/1999	72.1	76.2	0.85	93	77
8/1/1999	73.5	77.5	0.85	94	79
8/2/1999	71.1	74.9	0.83	88	81
8/3/1999	69.3	73.0	0.83	84	73
8/4/1999	68.3	72.4	0.83	88	69
8/5/1999	68.7	71.7	0.83	89	72
8/6/1999	69.0	73.0	0.83	87	75
8/7/1999	68.7	71.7	0.82	88	71
8/8/1999	68.3	71.1	0.83	81	71
8/9/1999	67.1	69.9	0.85	77	74
8/10/1999	63.9	68.0	0.84	78	64
8/11/1999	66.2	70.5	0.72	88	63
8/12/1999	69.8	73.0	0.77	90	74
8/13/1999	70.8	73.6	0.76	90	79
8/14/1999	72.0	74.3	1.1	86	79
8/15/1999	69.9	72.4	1.1	77	77
8/16/1999	69.4	72.4	1	83	71
8/17/1999	70.0	74.3	0.94	88	72
8/18/1999	70.6	73.0	0.85	83	76
8/19/1999	68.3	71.1	0.92	81	73
8/20/1999	65.4	67.4	1	71	70
8/21/1999	62.6	63.6	1.1	62	64
8/22/1999	62.6	64.2	1.1	67	59
8/23/1999	64.1	68.0	1.1	82	61
8/24/1999	66.1	69.9	1	83	67

8/25/1999	66.5	69.2	1	81	70
8/26/1999	66.8	67.4	1.1	70	70
8/27/1999	67.3	69.9	1.1	80	66
8/28/1999	68.5	71.1	1.1	85	71
8/29/1999	68.7	71.1	1.1	83	73
8/30/1999	63.2	65.5	0.98	68	71
8/31/1999	62.9	65.5	0.95	75	59

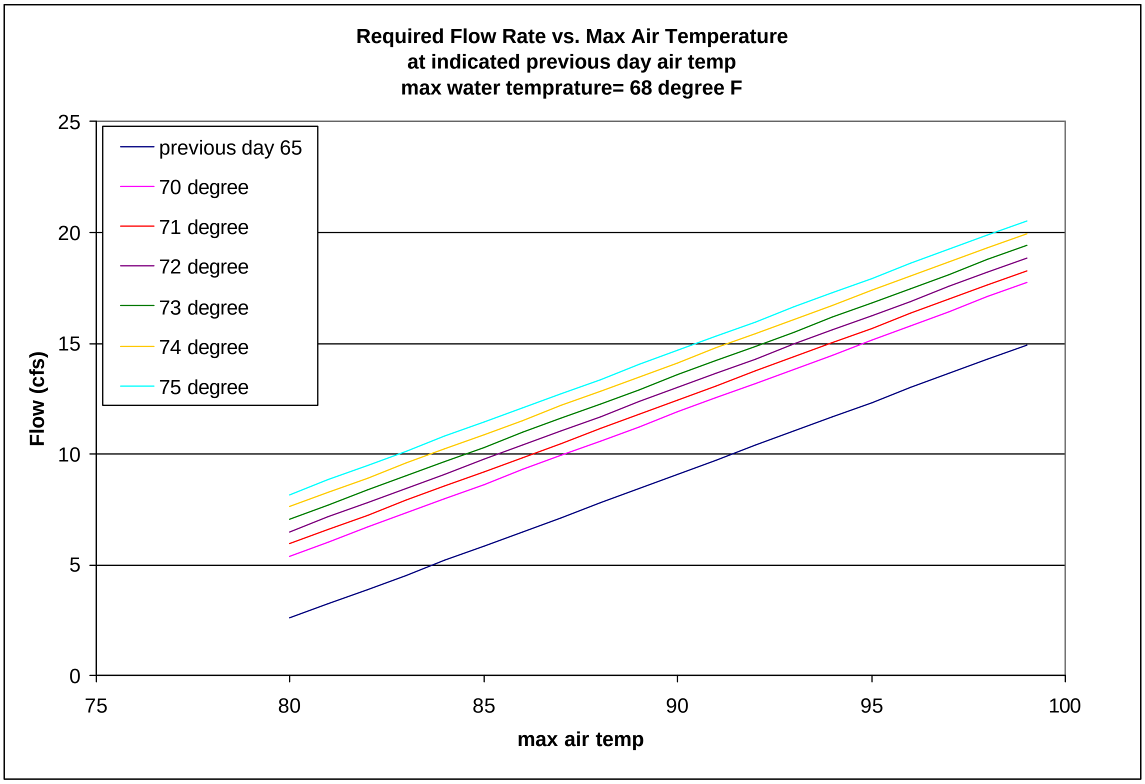
Source: Pequannock River Coalition data Macopin Station

To calculate the minimum passing flow requirement,
input max air and previous air temperature, in the right column

	input data
Maximum air temperature= T1	**99**
Previous day air temperature = T2	**82**
Maximum water temperature = T3	**68**
(T3= temperature criteria)	
Minimum passing flow Requirement (cfs)	**24.4**

To calculate the minimum passing flow requirement,
input max air and previous air temperature, in the right column

	input data
Maximum air temperature= T1	**90**
Previous day air temperature = T2	**75**
Maximum water temperature = T3	**68**
(T3= temperature criteria)	
Minimum passing flow Requirement (cfs)	**14.6**



Site No.	# days >68°F in 2000	# days >75°F in 2000	# days >68°F in 2001	# days >75°F in 2001
PQ1	20	0	97	26
PQ2	n/a	n/a	99	49
PQ3	48	1	n/a	n/a
PQ4	31	2	n/a	n/a
PQ5	88	7	13	1
PQ7	n/a	n/a	49	0
PQ6	n/a	n/a	44	0
PQ8	55	13	84	18
PQ10	27	2	92	9
PQ11	97	9	97	15
PQ15	n/a	n/a	6	0
PQ12	n/a	n/a	49	0

Source: Pequannock River Coalition

Table 5. Discharge Monitoring Reports with regard to effluent temperature along the Pequannock River and associated tributaries. Bolded values indicate those above the Surface Water Quality Standard value of 68° F.

Facility Name	Monthly Average Temperature based on permitted monitoring period		Temperature °C	Temperature Converted °F
	Monthly	Quarterly		

West Milford Twp. MUA-Highview	2000: July		19.4	66.9
	Aug.		19.5	67.1
	Sept.		18.2	64.8
	Oct.		15.0	59.0
	2001: May		14.4	57.9
	June		17.4	63.3
	July		18.9	66.0
	Aug.		**20.4**	**68.7**
	Sept.		18.5	65.3
	Oct.		15.3	59.5
	2002: May		13.9	57.0
	June		18.5	65.3
	July		**21.1**	**70.0**
	Aug.		**21.4**	**70.5**
	Sept.		19.4	66.9
	Oct.		16.3	61.3
	2003: May		14.8	58.6
	June		17.0	62.6
	July		**20.3**	**68.5**
	Aug.		**21.0**	**69.8**
	Sept.		19.1	66.4
	Oct.		14.8	58.6
Kinnelon Twp High School	2000: July		**20.4**	**68.7**
	Aug.		**20.3**	**68.5**
	Sept.		18.8	65.8
	Oct.		15.0	59.0
	2001: May		15.9	60.6
	June		**20.0**	**68.0**
	July		**21.1**	**70.0**
	Aug.		**22.8**	**73.0**
	Sept.		**20.1**	**68.2**
	Oct.		15.3	59.5
	2002: May		14.6	58.3
	June		19.8	67.6
	July		**23.4**	**74.1**
	Aug.		**22.3**	**72.1**
	Sept.		19.8	67.6
	Oct.		15.9	60.6
	2003: May		13.9	57.0
	June		**20.0**	**68.0**
	July		**22.4**	**72.3**
	Aug.		**22.3**	**72.1**
	Sept.		19.6	67.3
	Oct.		14.7	58.5
Vibration Mounting & Controls (2 outfalls / 2 temp. readings)		2000: May	**21.3** / 19.0	**70.3** / 66.2
		Aug.	**21.3/21.6**	**70.3/70.9**
		2001: May	18.8 / 18.4	65.8 / 65.1
		Aug.	19.6 / 17.4	67.3 / 63.3
		2002: May	**22.7/20.8**	**72.9/69.4**
		Aug.	**23.6** / 18.8	**74.5** / 65.8
		2003: May	**20.2** / 18.5	**68.4** / 65.3
		Aug.	**21.4** / 15.2	**70.5** / 59.4